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VARIABLE DOUBLE STARS.

By J. E. GORE, F.R.A.S.

VARIABLE stars are not as a rule close doubles, neither do the wider double stars include many examples of the variable class. Among the known binary or revolving double stars I do not know of a single instance—with the possible exception of 36 Andromedæ—of undoubted variation, although in some cases there exists a strong suspicion of inconstancy of light.

In speaking of double stars I refer to those which are actually seen to be double in good telescopes, for on the eclipsing satellite theory the variables of the Algol type must be considered as binary stars with very short periods, and with the component stars so close that even the largest telescopes yet constructed fail to show them as anything but single stars.

To the above rules there are, however, some notable exceptions. Perhaps the most remarkable instance of a variable star being also a close double is η Geminorum. The variability of this 3rd magnitude star was detected by Schmidt in 1865, and the reality of its fluctuations has been confirmed by Schönfeld and other observers, including the present writer. The total variation amounts to about one magnitude in a period which is somewhat irregular, varying in length from 135 to 151 days, according to Schmidt. Occasionally, however, its light remains constant, or nearly so, for several weeks at a time. The colour of the star is reddish yellow, and its spectrum a fine one of Secchi's 3rd type, a type to which many of the long period variables belong. In 1881 Mr. Burnham, the eminent American astronomer and discoverer of so many double stars, found the star to be a close double, the companion being of about the 10th magnitude and distant less than one second of arc from its comparatively brilliant primary. The difference of light is therefore about 7 magnitudes, indicating that the bright star is about 630 times brighter than the faint one. Mr. Burnham speaks of it as "a splendid unequal pair, and likely to prove an interesting system." Time will of course be required to prove the accuracy of this prediction, but should its binary character be established it will form a most interesting object, especially as hitherto no binary star has been found with a spectrum of the 3rd type.

Another variable star with a close companion is the short period variable S (15) Monocerotis. This star is the principal one of a small cluster known to astronomers as Herschel VIII. 5. The variable star, which fluctuates from about 5th magnitude to $5\frac{1}{2}$, has two faint companions of about the 9th and 11th magnitude. The 9th magnitude is distant about 3 seconds of arc from the brighter star, and the 11th magnitude about $17\frac{1}{2}$ seconds, and both may possibly have a physical connection with their primary. If the close pair are really in motion, the period of revolution must be very long, as a measure by Mr. Tarrant in 1888 shows an angular change of only 6 degrees since its discovery by Struve in 1832. The colours have been noted as greenish, and blue or pale grey. The spectrum is of the first or Sirian type. Additional interest is attached to this object from the fact that a distant companion (at about 76 seconds of arc) has been strongly suspected of variation in light from $8\frac{1}{2}$ to 12th magnitude. Observations by Mr. Tarrant in March and April 1888 tend to confirm this suspicion, as they show a difference in the estimates of its brightness of about $1\frac{1}{2}$ magnitude in about three weeks. This subject deserves more careful observation than it has hitherto received. A variable star with a variable companion would indeed be an interesting object.

A similar suspicion of variability is attached to a distant companion to the famous variable star Algol. This faint companion lies about 80 seconds of arc to the south of Algol. It was discovered in 1787 by Schroter, who suspected variation in its light; and observations in recent years tend to the same conclusion. In the early part of 1874 one observer failed to see any trace of it with a 7-inch refractor; but on September 9 of the same year, it was distinctly visible in the same instrument.* Sadler considers it probably variable from the 10th to the 14th magnitude in some short period. Three other faint companions were found by Burnham, one of them being distant less than 11 seconds from the suspected variable, which was estimated of the 10th magnitude by Burnham in September 1877, the companion being rated about $12\frac{1}{2}$ on the same evening. The others are of about the 13th magnitude, and form good comparison stars for the suspected variable, which Franks found "easy enough" with an $11\frac{1}{4}$-inch reflector on January 11, 1885, and about 2 magnitudes brighter than Burnham's companion.

The well-known variable star 68 (u) Herculis has also a tolerably close companion of about the 10th magnitude, distant about 4 seconds in 1878. Here we have also a difference of brightness of about 5 magnitudes, or a ratio of 100 to 1 in the relative brilliancy of the components.

Another interesting case is that of the well-known variable α Herculis. This is a double star with components of about the 3rd and 6th magnitudes, at a distance of about $4\frac{1}{2}$ seconds of arc. Measures of position from 1782 to 1876 show little or no change, and indicate no physical

* *Nature*, Feb. 20, 1879.

connection. Possibly the fainter companion may be much farther from us than the brighter star. The colours are orange, and emerald or bluish green, and the spectrum is a splendid specimen of the 3rd type. There seems to be some little doubt as to which of the components fluctuates in light; Sir W. Herschel and Argelander considered the brighter star to be the variable one, whereas Struve thought the variation was due to the fluctuations of the fainter component from the 5th to the 7th magnitude. It is not so easy to decide a question of this kind as might at first be supposed. Viewing a pair like this with a magnifying power sufficiently high to satisfactorily separate the components, they are seen in a small telescopic field of view completely isolated from other neigbouring stars of nearly equal lustre with which they might be compared. Observations with a wedge photometer might perhaps settle the question. Judging from the colours and spectrum, my own opinion is that the brighter star is the variable, and that possibly the fainter star may have merely an optical, and not a physical, connection with its brighter companion.

Another close double star which is almost certainly variable is Y Virginis (near 68 (i) Virginis). It seems to have no regular period, but, though usually of about the 6th magnitude, it was observed by Schmidt as bright as $4\frac{1}{2}$ magnitude on June 6, 1866. The Cordoba observations in subsequent years seem to confirm the variability, but possibly the star may remain constant in its light for lengthened periods. In 1879 Burnham found it to be a very close double star, the components being nearly of equal brightness and separated by only half a second of arc. Observations in recent years do not give much evidence in favour of orbital motion. The colour of the star is yellowish white, and the spectrum of the Sirian type.

Among variables with distant companions may be mentioned τ Cygni, to which Burnham found a 12th magnitude companion at 10 seconds; the Algol variable υ Ophiuchi, which has a very faint companion at a distance of about $20\frac{1}{2}$ seconds; υ ("Nova") Orionis, which has a $10\frac{1}{2}$ magnitude attendant at 30 seconds; δ Orionis, a 2nd magnitude star with a very faint companion at about 34 seconds, and a 7th magnitude at 53 seconds; and the short period variable δ Cephii with a 7th magnitude companion at 48 seconds.

Among stars certainly binary there is one, 36 Andromedæ (Struve 73), which is, according to Schmidt, variable to a small extent in periods varying from 40 to 125 days, but I am not aware that this variability has been confirmed by other observers. The components are of about the 6th and 7th magnitude, and the present distance between them a little over one second of arc. Dr. Doberck has computed an orbit for this pair, and finds a period of about 349 years.

Among the numerous stars which have been suspected of variable light, but which have not yet been admitted into the ranks of the regular variables, there are some interesting cases. The components of the well-known binary star γ Virginis have been suspected of alternate variation in brightness. In the years 1851 and 1852 Struve found the components sometimes exactly equal and sometimes differing by nearly three-fourths of a magnitude in favour of the southern star. In the years 1825 to 1832 he found the other component certainly the brighter. Franks found the southern star half a magnitude the brighter on March 28, 1885. Struve's suspicion seems to be confirmed by the observations of Fletcher, and the point seems deserving of more attention than it has hitherto received. An estimate of relative brightness might easily be made by those observers who measure at intervals the position of the components, and in this way interesting results might be obtained.

The companion of the double star Struve 547 has been suspected of variable light. It was estimated as $11\frac{1}{2}$ magnitude by Struve in the years 1829 and 1832; but Dembowski could not see it in 1865. Burnham, although gifted with keen eye-sight, failed to find it in 1873 and 1876. Gledhill was equally unsuccessful in 1879. The companion was, however, seen and measured by Mädler in 1845, by Burnham in 1877, 1879, 1880, and 1881, and by Gledhill in 1880. The latter observer found the distance between the components about $2\frac{1}{2}$ seconds, and his measure of angle (15·8°) seems to show some angular motion since its discovery by Struve in 1831.

A similar case is found in Struve 1058, in which the 11th magnitude companion to an $8\frac{1}{2}$ magnitude star was measured by Burnham in 1879 and 1881, but could not be found by Dembowski in 1865, nor by Burnham in 1874, 1875, and 1878.

In the double star Struve 1517 the observations of Struve, O. Struve, and Secchi seem to point to some variation in the relative brightness of the components. The measures of position since 1832 indicate a slow angular motion in the pair, which have also a common proper motion through space.

Struve 1932 is a double star in Corona Borealis, of which the components were estimated 5·6 and 6·1 magnitudes by Struve, 6 and 6·5 by Secchi, and 6·9 and 7·2 by Dembowski. Struve suspected variability, and my own observations with a binocular in the years 1885-1887 apparently show a small variation of light. The measures indicate a marked angular motion since its discovery in 1830, so that the pair is probably a binary.

The components of 36 Ophiuchi were rated $4\frac{1}{2}$ and $6\frac{1}{2}$ magnitude by Smyth in 1831. Sir J. Herschel estimated them both as 6th magnitude in 1834 and 1837. Dawes rated them both 5th magnitude in 1841, and so they were seen by Jacob in 1846. In 1854 Webb found them "nearly equal, about 6·5, Smyth's smaller perhaps rather the larger." In 1875 in India I noted them as "Both yellow, and almost exactly equal. The following star (Smyth's brighter component) if anything rather the brighter of the two." The measures show a well-marked angular motion of the pair, which is probably a binary as the components have a considerable common proper motion of about $1\frac{1}{4}$ seconds per annum. Curious to say, they are accompanied in their flight through space by the star 30 Scorpii which is distant no less than 13 minutes of arc from the binary pair.

One of the components of the double star O. Struve 256 has been suspected of variable light. They were rated 7·2 and 7·6 in 1848 by O. Struve, who made the *preceding* star in the field his primary. In 1867 Dembowski seems to have seen the *following* component the brighter, as his measures of position angle show. Perrotin in 1885 agrees with O. Struve and measured the position angle from the *preceding* star. On August 22, 1887 an occultation of the star was observed by Mr. J. Tebbutt at Windsor New South Wales. He had not at the time identified the star and was not aware that it was double. About three-fourths of the star's light at first suddenly disappeared, and about two seconds later "the rest of its light, which resembled a blurred star of the 9th magnitude, vanished quite as suddenly." This observation seems to show that on the date of Tebbutt's observation, the *preceding* star was *considerably* the brighter of the two components, and compared with Dembowski's measures, appears clearly to indicate variable light in one or other of the component stars. The pair is probably a binary.

XUM

HORNS AND ANTLERS.

By R. Lydekker, B.A.Cantab.

In a former article, entitled "Mail-Clad Animals," we treated of what may be termed the armature of animals for passive resistance; while in the present communication it is our intention to consider certain forms of armature adapted either for active resistance or for actual attack. Many forms of this type of armature, such as the tusks and claws of the Cat-tribe and other Carnivores, the pincers of the Lobster, the sting of the Bee and the Scorpion, and the poison-fang of the Adder, will at once present themselves to the mind of the reader; but on this occasion we propose to confine our attention to those types of armature commonly known as horns and antlers, which are now met with only among the Hoofed or Ungulate Mammals; although, as we shall mention in the sequel, the former were also developed in past epochs among a lower group of animals.

Fig. 1.—Head of Fallow-Deer, to show branching and palmated antlers.

It will, first of all, be essential to thoroughly understand what we mean by the terms "horn" and "antler," since, although both are purely English words, there is often great confusion in their application; the term horn being often applied to an antler, although the converse misnomer is never met with.

Commencing with antlers, it is scarcely necessary to say that the organs so named are the branching bony protuberances borne upon the heads of the males of most species of Deer during a certain part of the year. The nature of these appendages is well shown in the accompanying woodcut, drawn by Mr. H. A. Cole, from the head of a Fallow-Deer shot in Epping Forest in 1884. In the figured species the extremities of the antlers are flattened out, and are accordingly termed palmated; but in the Red Deer, and most other species, they are more or less completely cylindrical throughout the greater part of their length.

The most characteristic feature of the outer surface of an antler is its ruggedness, which reminds us somewhat of the bark of a tree, and is taken advantage of in the manufacture of so-called "buckshorn" knife-handles, &c. Antlers are, indeed, almost quite peculiar in that they represent, when fully formed, an entirely dead structure borne by a living animal as part and parcel of itself, and their mode of growth is very interesting. Thus, some time after a stag has shed its antlers, there appear on the summit of the skull two small velvety knobs, very tender and sensitive, and supplied by an unusual number of blood-vessels. These knobs, which are deposits of bony matter, very rapidly increase in size, and soon begin to branch into a number of so-called tynes, and finally assume the form of the complete antlers. It will thus be evident that even when fully grown the new antlers are still entirely covered with the soft skin known as the "velvet," beneath which the blood-vessels carry the blood to all their parts. With the final completion of their growth, and the cessation of the deposition of bony matter from the blood over the greater part of the antler, there is formed, however, at the very base above the point where the antler joins the protuberance on the forehead from which it takes its rise, a rough prominent ring of bone. This protuberant ring, which is commonly known as the "burr," and is often used to form the end of whip-handles, serves to constrict the blood-vessels at this point, so that henceforth no blood is carried over the antlers. In consequence of this deprivation of blood, the "velvet" rapidly dries up, and either peels off, or is rubbed off by the animal against the stems and branches of trees. The antlers are then complete, and their owner steps proudly forward from the sequestered glades in which he has lain concealed during the period of their growth as the "monarch of the glen."

This, then, is the mode of development of antlers; and after they have served their purpose as weapons of offence during the fierce encounters which take place between the males during the breeding season, the living bone beneath the skin at the base of the burr is absorbed, and the antler, or dead bone, is shed, to be again renewed in the same manner as before.

Another point in connection with antlers is, however, noteworthy—namely, that they gradually increase in complexity as the age of the animal advances. Thus, the head of the Fallow-Deer represented in Figure 1 evidently belongs to a fully-grown buck, for a young animal would have had much simpler antlers. Indeed, in the fawns of the first year the antlers of the Red-Deer consist only of a single prong, with a short front tyne; and year by year as they are renewed they acquire a greater and still greater number of tynes and branches, till they finally attain the complete stage, when their owner is termed a "royal hart." And a similar gradual increase in complexity takes place in the case of the Fallow-Deer and most other species. A few forms, however, like the Roe, always retain a comparatively simple type of antler, and thus recall the Deer of the middle Tertiary period, when none of the species had attained the complex antlers found in the larger living species. When we go still farther back in past time, and come to the lower part of the Tertiary epoch, we find, indeed, that the Deer had no antlers at all; and it is thus curious to observe, as in so many other instances, that the gradual annual increase in the complexity of the antlers of an individual of one of the existing species, is but an epitome of the gradual evolution during geologic times of the complex antlers of the living forms from the simple ones of their early ancestors.

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Great variation occurs in the form assumed by the antlers of the different species of deer. Thus, as we have said, in the Roe the antlers are simply forked, while in the fully-developed Red Deer they may have as many as sixteen points. In the Fallow-Deer the extremities only (Fig. 1) are distinctly palmated; but in the Elk, or Moose, the palmation embraces nearly the whole of the antler, and attains an enormous development. Of the species with cylindrical antlers those which attain the greatest development in this respect are the Canadian Wapiti, the great stag of the Thian Shan range, and some allied species from Sikkim and Persia. But the antlers which are found fossil in the peat and cavern-deposits of this country indicate that the predecessors of our own Red Deer attained equally gigantic dimensions. The extinct Irish Deer had, however, the finest antlers of any member of the family, their expanse from tip to tip exceeding 11 feet. Alone among the deer-tribe, the Reindeer of the northern regions of Europe and America has antlers in the female as well as in the male; thus indicating that in this instance the function of these appendages is connected with something else besides the combats of the males during the breeding season.

Fig. 2.—Skull of an Ox, showing the bases of the Horn-cores.

Having said thus much in regard to antlers, our next theme is that of horns, which we shall find to be of a totally different nature. The woodcut (Fig. 2) shows the bony skull of an extinct species of Ox, with the bases of the bony horn-cores; the tips having been cut away in order to save space. It will be seen that these horn-cores are bony prominences arising from the forehead, without any "burr" at their base, and forming, in fact, part and parcel of the skull itself. During life they are permeated by blood-vessels which traverse the whole of their interior, and they are coated by the hollow sheaths, to which the term horn is properly restricted. In structure these horny sheaths are merely a specially modified kind of skin, somewhat analogous to our own nails; and they are connected with the underlying horn-core by soft tissue and blood-vessels. Thus the horns of an Ox, Sheep, Goat, or Antelope, are essentially living structures—as we may see for ourselves in the case of an Ox or Cow which has had the misfortune to wrench off its horn from the bony horn-core; and are thereby totally different from the dead Antlers of the Deer. Moreover, with one remarkable exception, of which more anon, horns are never branched, and are never shed from their bony cores. In many instances, as in the Oxen, they are also common to the male and female; although those of the former are the larger. As in the case of Deer, however, we find that the earliest Oxen and Antelopes were devoid of horns, and that these appendages show a gradual increase in size as we ascend in the Tertiary period to the present day.

The one exception among the hollow-horned Ruminants (as the animals with true horns are often called), in which the horns are branched and are annually shed from their cores, is the Prong-buck of North America. In this elegant Antelope the horns have a single branch, and curve backwards in a hook-like manner. Another type of cranial appendage is exhibited by the well-known Giraffe, of Africa, which has a pair of short bony horn-cores on the forehead differing from those of any of the preceding forms. These horn-cores, which are some three inches in length, are cones of bone resting upon the forehead, from which in the young state they are entirely separate, although in old animals they become firmly united by bone with the skull. They are completely covered with skin, and appear to be of no possible use to their owner. They may, perhaps, be regarded as remnants of larger appendages found in certain extinct animals, which appear to have been in some respects intermediate between antlers and true horns.

The creature in which this intermediate type of cranial appendages occurs is the huge extinct Sivathere, of the Upper Tertiary deposits of Northern India, which is the largest known representative of the Ruminants, or cud-chewing Mammals. This animal was provided with huge wide-spreading antlers (although it is here difficult to say whether we should use the term antler or horn), somewhat like those of the Elk, but apparently permanently attached to the skull, since they show no "burr" at the base. These antlers were, in all probability, always covered either with skin or with very thin horn, and thus seem to indicate that the difference between an antler and a horn is not so great as appears to be the case when our studies are confined to living animals.

The last form of horn we have to mention among existing animals is that found in the Rhinoceroses. And here we have to observe that whereas the antlers of the Deer and the horns of the Oxen are placed in pairs on either side of the skull, in the Rhinoceroses the horns or horn (for there may be either two or one) are placed in the middle line—one in front of the other when two are present. In structure these horns would be comparable to the horn of an Ox, if the latter had no bony core, and were filled up internally with the same horny material as that which forms its outer surface. These horns have no solid attachment to the underlying bone, and are thus only excessive developments of skin-structure, more analogous in structure to warts than to anything else with which we can compare them.

The extinct animals from the tertiary of the United States known as Titanotherer, which were somewhat akin to Rhinoceroses, are distinguished by having a transverse pair of bony horn-cores above the nose, which during life were doubtless sheathed in horn. Again, the Uintatheres, of the same region, were another type of huge Ungulates, having as many as three pairs of bony horn-cores; and thus being the most extraordinary creatures of this group of animals at present known to us.

XUM

The above are the three great types of the offensive armature with which the skulls of existing Mammals are provided, and they are all of them, as already observed, found in the order of Hoofed Mammals, and nowhere else, at the present day. If, however, we go back to the long-distant Mesozoic epoch, or period, at which our chalk was deposited at the bottom of the sea, we find that certain herbivorous species of the gigantic reptiles known as Dinosaurs (of which we hope to speak in a future article) were provided with paired bony horn-cores on their skulls, so exactly resembling those of our own Oxen that some of them when found detached were actually described as belonging to an extinct Bison. In the later Tertiary beds of Australia, we also find a huge tortoise with somewhat similar horn-cores on its forehead; and since these horn-cores, both in this and the preceding instance, so closely simulate in structure those of the Oxen, we may fairly infer that they were similarly sheathed with true horns during life.

Thus we learn that in long past epochs not only was the place of the larger herbivorous Mammals of the present day taken by various forms of giant herbivorous reptiles, but that those reptiles were actually armed with weapons precisely similar to those of the Mammals of the present day. So true is it that there is "nothing new under the sun."

OLD HINDU ALGEBRA.

In India, at the time of Âryа-Bhaṭṭa 1,700 years ago, minus quantities were distinguished by a dot over the coefficient, all unmarked quantities being held to be positive or plus. Multiplication was indicated by a dot between the factors; and division by placing the divisor under the dividend, much in our own way; but squares, cubes, unknowns, &c., were indicated by initial letters of the words expressing the ideas, thus—

v for *varga*	= square.
gh for *ghana*	= density, cube.
gu for *guna*	= multiplication.
rû for *rûpa*	= form, the definite quantity.
&c.	&c. &c.

Coefficients were placed *after* the literal symbols; and an unknown quantity was generally expressed by *y*, the initial of *yâvat-tâvat*, "this-much-that-much," or "any-much." Other unknowns to any number were expressed by initials of the names of colours. An instance will show the use of these symbols; thus for—

$$12\,x^2 + \tfrac{2}{3}\,x^3 - 3\,x^2\,\frac{4\,x^3}{x^2}$$

the ancient Hindus wrote—

$$yv\ 12\ ygh\ \tfrac{2}{3}\ yv\ \dot{3}\ .\ \frac{ygh\ 4}{yv\ 1}$$

Their method of writing an equation was more awkward than ours, and while everything else is so obvious the reason for it is not apparent; thus for—

$$12\,x^2 - 3\,x^3 = 14$$

they would write—

$$\begin{array}{llllll} yv & 12 & ygh & \dot{3} & rû & 0 \\ yv & 0 & ygh & 0 & rû & 14 \end{array}$$

The second line is given as the equivalent of the first line, ciphers being supplied where required.

FREDERIC PINCOTT.

WHY IS THE SEA SALT?

By W. MATTIEU WILLIAMS.

(*Continued from p.* 179.)

In my last I described the variations in the degree of salinity of the ocean, and the causes of such variation, and concluded by reference to the apparent paradox that the river-flows which are reducing immediate local salinity are the main sources of the general salinity.

The paradox vanishes when we consider the fact that the ocean simply occupies the lower valleys of the earth, and that the dry land consists of its mountain summits and their upper slopes only. This portion of the earth slopes towards the main or oceanic valley, and thus all the drainage and washings of the exposed land surface proceed to the ocean. The insoluble portion of these washings are deposited as ocean-bed strata, the soluble portions remain in solution in quantity dependent on their solubility. River-water or spring-water, as we all know, is more or less "hard," but the rain-water, from which all these hard waters are derived, is "soft."

The hardness of the hard water is due to saline impurities held in solution; the softness of soft water, to the absence of these. The ocean is being continually distilled by solar heat, and the distilled water, thus lifted into the atmosphere and falling on the earth as rain, is pure, soft, or free from saltness. Therefore the saline materials which give hardness to the river-water are derived from the land, and must be left behind in the sea.

It is true that the quantity of such saline matter dissolved in the water that enters the sea at the mouths of rivers is very small, but "many a mikle maks a mukle," and this everlasting supply of small contributions that has been going on as long as the surface of the earth has consisted of land and water, is amply sufficient to account for the *quantity* of salt in the ocean.

If this explanation is correct, a confirmation should be found in all inland bodies of water, all lakes and seas that have no outlet. The great Canadian lakes, the lakes of Constance, Geneva, &c. are merely outspread rivers—streams that pour into a deep, wide valley at one end and run out of it at the other. Thus, the Lake of Geneva is but an outspread of the Rhone, the Lake of Constance an outspread of the Rhine. But there are other lakes with no such lower outlet—lakes that only retain their normal level (as the ocean does) by evaporating as much as they receive from rain and the river or rivers that supply them. As they thus receive hard or slightly saline water and give off only soft or pure water, they should represent the ocean in respect to salinity. This is the case. Many are more strongly saline than the sea itself. This is especially the case in hot countries, where the amount of evaporation is great.

The Dead Sea is a popular example of this. It occupies a deep trough-like valley, and receives at one end the famous river Jordan, and at the other, and from its sides, a multitude of minor rivers and rivulets. The whole of this surplus supply of water is removed by solar distillation; the amount of such distillation varying—other conditions being equal—with its surface. As the land is sloping on all sides, the height of the lake cannot increase without a corresponding increase of surface and consequent increase of evaporation. Thus an automatic regulation is perpetually maintained. If the river supplies diminish, the area of surface of the lake and the amount of evaporation diminish, and *vice versâ*. The excessive briny saltness of this lake is well known and easily accounted for by the above explanation.

XUM

Such model oceans are especially abundant on "the Roof of the World," that great table-land of Asia, extending northward from the Himalayas and their eastward extensions to the Altai Mountains, &c. A detailed map of this strange country is dotted over with figures, of tadpole shape, or of bags with strings attached. The strings are rivers, the bags are salt lakes, most of them of briny saltness. Many are surrounded with salt deserts, evidently the beds of their ancient greater extension. I suspect that during the great European glacial epoch, when there was more rain and less evaporation, these cul-de-sac lakes were united to form a great Asiatic Mediterranean sea. The Sea of Aral and the Caspian are larger examples of the same series. The saltness of these is commonly supposed to indicate their former communication with the ocean; but their surroundings contradict this, and what I have explained above removes the demand for the geographical violence involved in the supposition. Even if we assume that the Caspian was formerly connected with the Black Sea, it was still beyond the reach of ocean or even Mediterranean salt, as the Black Sea pours outwards through the Bosphorus into the Sea of Marmora, and this still outwards through the Dardanelles, all downwards to the Mediterranean.

Many analyses of sea-water have been made, the results displaying notable variations, as I have already stated. The following present an approximate average, as selected by Dr. Miller:—

	British Channel.	Mediterranean.
Water	964·744	962·345
Chloride of sodium	27·059	29·424
Chloride of potassium ...	0·766	0·505
Chloride of magnesium ...	3·666	3·219
Bromide of magnesium ...	0·029	0·556
Sulphate of magnesia ...	2·296	2·477
Sulphate of lime	1·407	1·357
Carbonate of lime	0·033	0·114
Iodine	traces	—
Ammonia	traces	—
Oxide of iron	—	0·003
	1000·000	1000·000

In quoting these (the first is by Schweitzer, the second by Usiglio), I should add that all such statements of analytical results involve a certain amount of hypothesis. The existence of the elements there named are demonstrated as fact, and also their quantities; but the mode of their grouping as compounds is merely inferred. Thus some of the chlorine which is there given to the sodium, the potassium, and the magnesium, may be actually associated with the calcium, and a corresponding amount of the sulphuric acid described as combined with the lime may be actually associated with soda. The further discussion of this is not demanded here, and the subject is still obscure; but there is one remarkable and highly instructive feature which exists independently of the hypothetical assumptions. It is this: *the materials most abundant in the saline constituents of sea-water are just those earth materials that are the most soluble in distilled water.*

Every student who has gone through his first practical lessons in chemical analysis knows that, with one exception, he precipitates all the metals by causing them to form insoluble compounds, this exception being sodium, and that in ordinary course he finally estimates this as soluble chloride, which he evaporates down to dry crystals. This (our common table-salt) is the leading, the characteristic salt of sea-water. There is another base that forms equally soluble salts to those of soda, viz. ammonia, but this is not a constituent of the inorganic rock material of the earth's crust, and therefore its comparative absence rather favours the general view I am advocating,

Still more elaborate analyses than those I have quoted have been made, analyses conducted for the purpose of discovering quantities too small to be detected by ordinary means. Very large quantities of sea-water have been evaporated down and the above-stated constituents removed. By skilful application of this principle the obscure, excessively diluted constituents have been concentrated and rendered evident. Thus have copper, silver, gold, and many other metals been found in such quantities as to suggest that, if we proceed far enough, we may find all the materials of the earth dissolved in sea-water in proportions bearing some relation to their solubility and their abundance on the earth's solid surface. For example, Sonnenstadt found $\frac{9}{10}$ of a gramme (about 14 grains troy) of gold in every ton of sea-water. Otherwise stated, eight tons of sea-water contain, within a small fraction, the same quantity of pure gold as we have in an English sovereign. Therefore, taking the whole weight of the ocean in tons and dividing by eight, we have the value of the gold dissolved in the ocean expressed in pounds sterling.

The saltness of the sea has been attributed to the solution of beds of rock-salt. This I believe to be just the converse of the truth. The sea has not obtained its salt from such deposits, but such deposits have obtained their salt from the sea or inland salt-lakes. The salt occurs more or less admixed or interstratified with marine or lacustrine deposits, indicating the existence of an ancient sea or lake bottom from which the salt water has been evaporated, forming first a salt-lake, then brine pools, and finally the existing saline strata.

I visted the "Salines" or salt-mines of Bex in Switzerland many years ago, travelled a considerable distance underground, expecting to see some of the glistening crystal walls and grottoes of which I had read as displayed in salt-mines; but, instead of these, found nothing but long dark passages and galleries cut in dingy, grey, mud-like rock. This is a characteristic example of such saline deposits. They usually consist of dirty sulphate of lime intermingled with grains of salt. The salt is obtained therefrom by dissolving it out with water and then evaporating the solution. When the water reaches it by natural infiltration salt-springs and salt-wells are formed, and the supply is obtained by pumping from these. Such is the case in Cheshire, Droitwich, &c.

Now let us see what would occur if we were to fill a tank with ordinary sea-water, and evaporate away the pure water. The first observable result would be general turbidity. On examination we should find this turbidity to be due to the gradual precipitation of sulphate of lime (plaster of Paris), which, being the least soluble of all the salts named in the above analyses (excepting the carbonate), would be the first to come down in notable quantity. Next to this, and simultaneously with its continuation, would occur the deposition of crystalline grains of chloride of sodium, the other salts following. If the water had been taken from the deep sea and perfectly clear, the saline rock thus formed would be white and glistening; if from estuarine shallow turbid water, it would be darker or more or less dirty, like the rock matter at Bex. That it should usually be thus dirty is only what is likely to occur under the conditions of silting up and shallowing that must accompany the isolation and evaporating down of a body of sea-water or salt-lake water.

THE BED-BUG.—I.

By E. A. Butler.

IT has already been pointed out that the migrations of some insects are largely dependent upon the commercial enterprise of nations, and that it is to our own widely extended commerce that we can trace the introduction into this island of our kitchen pest, the common cockroach. We have now to consider another and much less desirable importation, which we owe to a similar source. The bed-bug, though now, unfortunately, firmly enough established, is not indigenous here, and appears to have been known as British for about the same length of time as the cockroach, although it is, of course, impossible to assign a definite date for its introduction. Like the cockroach, it appeared first in seaport towns, whence it spread to other parts; but its advance to inland regions was slow, if we may judge from a *brochure* entitled *A Book of Buggs*, written by John Southall in the year 1730, in which he points out that at that date, *i.e.* nearly two hundred and fifty years after we first hear of the insect, though "not one seaport in England is free from them, in inland towns buggs are hardly known." The earliest record of its occurrence in Britain is to be found in a Latin treatise on *Insects or Minute Animals*, by Thomas Mouffet, published in 1634. This writer, who does not state whence he obtained his information, says that in the year 1503, two ladies of noble family, residing at Mortlake, became greatly alarmed at finding themselves one morning bug-bitten, not knowing the cause of the inflamed swellings which had appeared upon their persons, and thinking they had contracted some frightful contagious disease. That even at this early date the insects were not entirely unknown, though certainly strange, appears from the ease with which the disquietude of the noble sufferers was allayed by their physician, who was at once able to point out to them the real cause of their disfigurement.

The inelegant monosyllable we are now accustomed to use as the name of this horrid parasite does not seem to have been applied to it at first; even Mouffet, who speaks of it in Latin as *Cimex*, gives as the English equivalent of this, "wall-louse," but does not mention the word "bug" at all. This, however, is only negative evidence; and as there appears to be an undoubted reference to the insect under the shorter name in a play of Massinger's dated twelve years earlier than Mouffet's treatise, it must have been at least in occasional use at that period. "Chinch" is another old name for it, which appears to have become extinct only a generation or two ago.

The origin of the modern name is somewhat obscure. As applied to the insect, the word "bug" has usually been supposed to be identical with the old British word of the same form, meaning a hobgoblin, or nocturnal apparition, a word still existing in the compound "bugbear"; and the idea was that the name was transferred to the insect in consequence of its nocturnal and disgusting habits, and the alarm they occasioned when, as in the instance above referred to, the cause was unknown. But, as Dr. Murray points out in the new English Dictionary, this is mere conjecture, and no direct evidence of the transference of the name is forthcoming; hence it is safer to regard the etymology of the word, as applied to this and other insects such as the May-bug, &c., as at present unknown. In Shakespeare the word occurs several times, in the sense of a spectre, but never as the name of the parasite, which, indeed, does not appear to be mentioned by that observant author, a tolerably good indication that it was not very common in his time. Southall, indeed, maintains that when he wrote, bugs had been established in England only for about sixty years, which would throw their first appearance down to the year 1670; but this idea is plainly refuted by the notes of time already mentioned.

To English entomologists the bed-bug is now known as *Acanthia lectularia*; it is the insect which Linné called *Cimex lectularius*, a name by which it is still frequently spoken of. *Cimex* was the name by which it was known to the Romans, and hence was selected by Linné as the generic term for bugs in general; the specific name *lectularius* is derived from the Latin word for a couch or bed, and of course refers to the locality in which we most frequently meet with it.

Though annoying us in the same way as the flea, the bed-bug is yet a totally different sort of insect, and in its life history departs as widely as possible from its companion bedroom pest. The flea, it will be remembered, we regarded as a sort of wingless fly, and therefore located it in the order Diptera; the bug, on the other hand, belongs to the order Hemiptera, and finds some of its nearest allies in the plant bugs, water scorpions, water boatmen, skaters, &c. The most fundamental distinction between these two orders lies in the nature of the metamorphosis. The Diptera, or Flies, as we have already shown, pass through the usual changes in the course of their development, appearing first as a grub or maggot, next as a limbless, motionless chrysalis, and then as the perfect fly; but the Hemiptera or Bugs, pass through no such remakable alterations of form, and in their early life show a general resemblance to what they will ultimately become, differing from the adult chiefly in size, and depth of coloration, and in the absence of wings and the immature condition of the reproductive organs. Thus, while the young flea, when hatched from the egg, is a wriggling, worm-like creature, without limbs, and utterly unlike its parents, the young and newly hatched bug is a six-legged running creature, to all intents and purposes a miniature reproduction of its parents, and a forecast of what it will itself in a few weeks become. Hence fleas and bugs, though alike in blood-sucking habits, and human parasitism, are yet almost at opposite poles in the series of developmental types.

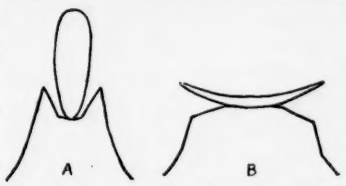

Fig. 1.—Diagrammatic Section of Body of (A) Flea, and (B) Bed-Bug.

In the form of the body, again, there is the strongest possible contrast between these two parasites. Both are extremely narrow in one direction, and broad in another; but in the flea, the body is extended vertically and contracted laterally, and in the bug it is extended laterally and contracted vertically; the former is *com*pressed, the latter *de*pressed. Fig. 1, representing diagrammatically a vertical transverse section of the two insects, strikingly shows this difference. The extremely depressed and flattened form which the bed-bug exhibits is by no means exceptional in the order Hemiptera, in fact this order contains amongst its species by far the flattest of all insects; "B flat" is a sobriquet not more applicable to the bed-bug than to several other kinds that are not parasitic at all. Such flatness is always associated with the habit of hiding in cracks and crevices—a habit in which, everyone knows, our bedroom pest is a perfect adept. In flatness, however, it does not equal a certain wild British species which lives under the bark of willow-trees, and has a body of almost paper-like thinness.

The disgusting odour which attends the bed-bug would

alone be sufficient to excite repugnance and to prevent its habits from being much studied. But as this smell completely goes off after death, there is nothing but the natural prejudice against a personal parasite, and one so closely associated with uncleanly conditions, to render a careful examination of the dead insect an unpleasant experience. There are many delicate touches in the portraiture even of an insect which, when alive, is so repulsive; it is not all coarseness and vulgarity, and the compound microscope, the use of which is necessary to make out the minuter details, reveals many interesting features.

For examination the insects may be killed by being plunged into *boiling* water, or by being exposed for a time to the fumes of chopped laurel leaves. In either case, their sickening smell soon disappears. Even at their largest, they are not more than a quarter of an inch long, and hence are too small and delicate to be touched with the fingers without great risk of damage, and a pair of fine forceps is necessary for handling them. When fully grown they are of a deep rust-red, tinged with black here and there in the abdomen. The head and fore-parts are somewhat lighter than the rest of the insect. Of the three divisions of the body, the head (Fig. 2) is the smallest; its hinder part is of an oblong shape, broader than long. The eyes form projecting knobs at the sides, and the base of the mouth organs a considerable prominence in front, whereby the head, as a whole, acquires roughly a pentagonal outline.

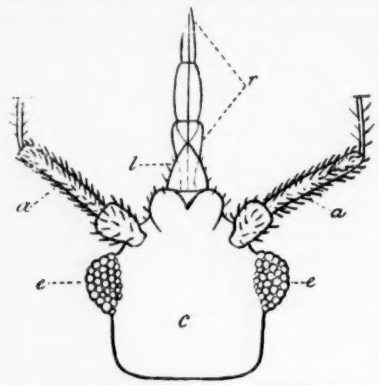

FIG. 2.—HEAD OF BED-BUG, WITH ROSTRUM EXTENDED. *a*, antennæ; *c*, crown; *e*, eyes; *l*, labrum; *r*, rostrum.
N.B.—The last joint of the antennæ and part of the next have been removed.

The mouth organs form a sort of beak, called the *rostrum*, and this, as is usually the case in the Hemiptera, is tucked back underneath the head (Fig. 3), running along the central line as far as the base of the first pair of legs, the head being slightly grooved beneath for its accommodation. At its junction with the head, the rostrum is more flexible than elsewhere, so that it can be brought out from the position of rest and held either pointing vertically downwards, or even sloping forwards, when required to be used. By reason of the constant presence of such a beak-like apparatus as this, the name Rhynchota, *i.e.* beaked insects, is frequently used instead of Hemiptera as the name of the order. Lapping over the front of the beak, at the spot where it joins the head, is a triangular plate, the labrum, or upper lip (Fig. 2, *l*). The beak itself (Fig. 2, *r*) consists of a three-jointed, tubular, or rather gutter-shaped organ—the labium—the channel of which is closed above (*i.e.* on the surface which is forward-looking when it is in use) by a thin transparent membrane, which is easily ruptured. Within the channel lie, side by side, and perfectly free, four fine, straight, bristle-like organs, which represent the mandibles and maxillæ of other insects. The mouth is therefore of the suctorial type, and suited only for feeding upon liquids; but it is adapted, not solely for sucking up exposed juices, as is that of butterflies and moths, nor for licking them up like that of bees, but for getting at liquids which are enclosed within covers or boundaries which need to be pierced before their contents can be reached. There is thus no power of biting, strictly so called; hence the term "bug-bite," like "flea-bite," is somewhat inexact.

FIG. 3.—SIDE VIEW OF HEAD OF BED-BUG, showing position of rostrum (*r*) in rest.

In the presence of this boring apparatus, the whole order of bugs agrees with many of the flies, notably with gnats and mosquitoes, whose piercing bristles create so much pain by the minuteness of the punctures they make in our skin. Notwithstanding the general agreement, however, there is one strongly marked difference between the two orders; flies always have one pair of palpi and sometimes two, attached respectively to the maxillæ and the labium, but no such organs are ever found in bugs; hence the mouth in the Hemiptera is of a simpler construction than in the Diptera, through the suppression of parts which are, except in this order, almost universally present, and generally very prominent. This suppression and simplification is the more remarkable because the bugs are in some respects a more primitive race of insects than the flies, and might so far have been expected to show a more generalised type of mouth. It is impossible at present to do more than speculate as to the significance of this absence, as separate organs, of parts which are in most insects amongst the most prominent of the food-taking apparatus, and which are endowed with such a power of persistence, so to speak, that in some cases they remain distinct after the organs to which they belong, and of which they are appendages, have become fused with the rest, or have disappeared altogether. Too little is yet known of the function or functions of palpi in general, to be able to imagine what can be the influence upon the economy of the insects of the defect under which they labour. One would think that by contrasting the habits of the not-palpi-possessing Hemiptera with those of the palpi-possessing Diptera, it would become possible, by detecting constant differences between the two orders, to arrive at some valid conclusion as to the function of these organs. Such, however, does not seem to be the case, and if there is any marked difference in the way of taking the food, or in other respects, it has yet to be discovered; we know no more why the blood-sucking mosquito should possess palpi, than why the equally blood-sucking bug should be without them. Some maintain, however, that the channel-like beak itself consists of the fused labial palpi instead of the pair of jaws to which they belong, in which case the above remarks would lose some of their force.

FIG. 4. — PIERCING APPARATUS OF BED-BUG. *md*, mandibles; *mx*, maxillæ.

Of the two pairs of bristles (Fig. 4) one (the mandibles) is considerably stouter than the other (the maxillæ), and the latter are exceedingly fine and delicately saw-like at the free end. Each mandible possesses a sort of flange, along which the corresponding maxilla slides, and thus the four bristles unite into one boring weapon. As everyone knows, the wound this weapon can inflict is, at least in some cases, exceedingly painful and productive of considerable inflammation. Not that any poison is instilled

into it, so far as appears, but the very minuteness of the punctures seems to be the cause of the irritation, just as a prick with an exceedingly fine needle often causes intense pain.

(*To be continued.*)

ON SOME RECENT ADVANCES IN THE MAPPING OF THE SOLAR SPECTRUM.

By A. C. RANYARD.

THE third volume of the *Annals of the Nice Observatory* has just appeared, accompanied by an atlas of 17 plates, in which M. Thollon's beautiful drawings of the solar spectrum have been represented by carefully executed steel plates, engraved and published at the expense of M. Bischoffsheim. The atlas represents the fruits of between six and seven years close application of a man of remarkable ingenuity and exceptional gifts; and the engraver, with the aid of M. Perrotin, the Director of the Nice Observatory, has been occupied for more than three years, since the death of M. Thollon, in reproducing the drawings.

M. Thollon's map of the spectrum was made with a large bisulphide of carbon spectroscope kept at an even temperature by water circulating within the table on which it was mounted, and also within a large double-walled metal box which descended from the ceiling and covered the instrument. The light of the sun was thrown from a heliostat on to the slit of the collimator which passed through one side of the metal box, and the observer looked through a telescope passing through the other side of the box. All adjustments of the prisms and other internal parts were made by rods and cords passing through the sides of the box, while cold water was constantly kept circulating around the instrument. With this spectroscope M. Thollon made his chart of the spectrum extending from the Great A group at the red end of the visible spectrum to *b* in the blue green. The maps put together are more than ten metres long, and contain more than three thousand lines. Not only was the position of each line carefully determined, but its thickness and blackness and the character of its nebulous edges were portrayed with conscientious accuracy, and its behaviour was studied when the sun was at different altitudes. Each portion of the spectrum is represented by four bands, the upper one of which represents the solar spectrum as observed when the sun is at a distance of 80° from the zenith and the air is neither very dry nor very damp. The second band represents the spectrum as seen when the sun is 60° from the zenith and the air is very damp. The third band represents the spectrum as seen when the sun is 60° from the zenith and the air is very dry. The fourth band contains all the lines of exclusively solar origin, and has been constructed by prolonging the lines which remain unaltered under varying atmospheric conditions.

At the time when M. Thollon commenced his mapping of the spectrum, and up to the time of his death, he did not imagine that photographs would so soon be taken which would show all the detail which can be seen by the eye with a spectroscope of large dispersion. It would have been impossible to photograph with his bisulphide of carbon prisms, though they gave a much more brilliant spectrum than can be seen with similar dispersion and a grating spectroscope, for during the time necessary to expose a plate slow changes of temperature would sufficiently alter the refractive index of the bisulphide of carbon to shift the place of the lines on the sensitive plate, and the photographic action of light in a great part of the region mapped by M. Thollon was very slow with the processes then known.

In 1880 Prof. H. A. Rowland, of Johns Hopkins University, a brilliant young American physicist and mathematician, devised a plan by which he was enabled to overcome the chief practical difficulties which mechanicians had up to that time encountered in cutting accurate micrometer screws. This enabled him to succeed in ruling diffraction gratings containing up to 43,000 lines to the inch, without an appreciable periodic error amounting to the hundred-thousandth part of an inch, and it almost entirely got rid of the ghosts which were so frequently seen overlying the spectra thrown by the earlier gratings. These were due to the recurrence of groups of narrower and broader spaces at periodic intervals which gave their own spectrum, and caused ghosts of the more prominent lines sometimes on both sides of them.

In 1881 the happy idea occurred to Prof. Rowland that a diffraction grating might be ruled on a spherical surface, and that by this means the spectrum might be brought to a focus without any lenses, thus reducing the spectroscope to its simplest form, and avoiding the cumbersome adjuncts of collimator and viewing telescope, as well as greatly facilitating physical researches in the parts of the spectrum where it had hitherto been found necessary to use rock salt or quartz lenses.

In 1886 Prof. Rowland completed and published copies of a photographic map of the normal solar spectrum, taken with one of his concave gratings of six inches in diameter and 21½ feet radius. It extended from wave-length 3680 to 5790; that is, from above H down nearly as far as D. The region in the neighbourhood of H is on four times the scale of Angström's map; the region at the less refrangible end is on twice the scale, and the intermediate portion is on three times the scale of Angström. The definition was so good that 1474, b_3, and b_4, are shown clearly as double, and E, though not distinctly split, can be easily recognised as double. In 1889 Prof. Rowland published a new series of photographs of the spectrum, extending from wave-length 3000 to wave-length 6950, which showed a distinct advance in definition on the former series.

Another very marked step in advance has been made by Mr. George Higgs, of Liverpool, to whom we are indebted for the beautiful photographs of the portions of the solar spectrum which accompany this paper. He has made use of one of Prof. Rowland's concave gratings of four inches diameter, with a radius of curvature of 10 feet 2 inches, which gives less than half the dispersion of the 21½-feet grating used by Prof. Rowland; but the photographs he has obtained are decidedly sharper, and show more lines than those of Prof. Rowland. For instance, Mr. Higgs counts 22 lines between D_1 and D_2 on his original negatives. I have recently made a visit to Liverpool to endeavour to learn something of the means by which Mr. Higgs has obtained such sharp definition. It seems to be owing to extreme care in making his adjustments, and to the very fine steel-jawed slit which Mr. Higgs has made for his instrument. He has been occupied for some years with experiments on the photography of the solar spectrum, and has made an extended series of experiments on the dyes for sensitive plates which enable photographs to be taken in the infra red and ultra violet regions, and he now proposes to publish a photographic map of the spectrum, extending from wave-length 2990 to wave-length 8500. Each section will be photographed coincidentally with some other portion of the spectrum belonging to a different order, so as to give a natural scale, by which any possessor of the photograph may determine the relative wave-lengths of the lines

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shown. This necessitates the photographing of two differently coloured regions of the spectrum on the same plate, and greatly adds to the difficulty of the problem of selecting suitable dyes.

Practically all that is ordinarily required is the relative wave-length; from it the absolute wave-lengths may be determined when we know the absolute wave-length of any line. One of the most thorough investigations of an absolute wave-length has been made by Mr. Louis Bell, of Johns Hopkins University. He gives the wave-length of the D_2 line as 5890·188 tenth-metres, which exceeds the measure as obtained from Thalén's correction of Angström's value by about one-fifth of a tenth-metre. Prof. Rowland has followed this by a table of the relative wave-lengths of about 450 standard lines based upon Bell's investigation. He gives the wave-length of—

C = 6563·042	D_1 = 5896·156	D_2 = 5890·188		
K. 1474 = 5316·877		E_1 = 5270·497	E_2 = 5269·720	
b_1 = 5183·798	b_2 = 5172·867	b_3 = 5169·159	b_4 = 5167·580	
G = 4293·245				

The spectrum as photographed by Mr. Higgs is on about one-fourth the scale of the enlargements shown in the illustration. Four portions of the spectrum are given on each plate. The reader may possibly be confused by two different regions having been placed adjacent to one another, but the line of junction separating the two regions will easily be seen; they were placed in contact so as to lose no room and get as much of the spectrum on to the page of KNOWLEDGE as possible.

Section 1 represents the Great B group. Most of the lines in this group are certainly telluric, as well as in the curiously similar group Great A, which has been photographed by Mr. Higgs, but is not given in our plates. These groups are so curiously similar that one is tempted to suspect some harmonic relation between them; but there are no similar groups in other parts of the spectrum, although a region corresponding to much more than two octaves of wave-lengths has now been photographed. The first line in what has been termed the head of the B group is triple, as seen in Mr. Higgs's negatives, and it can be just recognised as triple in our plates. The tail is a fluting, consisting of several pairs thinning off and mixing with other solar lines. At 6930 there is a group of five lines, the first and fourth of which belong to the fluting, and increase markedly in blackness with a low sun, becoming much more conspicuous than the true solar lines.

Section 2, the D line region. This portion of the spectrum has been photographed by Mr. Higgs with dry plates stained with erythrosine and cyanine, which greatly increases their sensitiveness to the green and orange region of the spectrum, and has enabled him to photograph all the lines which can be seen with the eye, a result which had not been before obtained. Cyanine adds sensitiveness to the ordinary bromo-iodine dry plates down to the infra red regions. Many interesting experiments have been made with respect to such colouring substances by Mr. Higgs. He finds, for instance, that in the neighbourhood of the A region the sensitiveness may be increased a thousandfold by staining with some of the dyes of the anthracene series.

This group embraces the D lines, and the two so-called rain-bands (wave-length 5914 to 5926 and 5940 to 5960) close to it. Most of the lines in the rain-band groups, and certainly ten of the lines between D_1 and D_2, are due to aqueous vapour in our own atmosphere. With a high sun these atmospheric lines are much reduced in intensity, and some appear to vanish altogether. The spectrum here reproduced was taken with the sun from 10° to 15° high. 5884 is a double line on the original negative. One of its components is atmospheric, the other solar; and coincident with an iron line; the same remark applies to 5914·3. One of the components of each is consequently variable, while the other is constant.

Midway between the two D lines is a nickel line, but the other lines between the D_1 and D_2 have not yet been matched with laboratory spectra. Mr. Higgs has taken photographs showing the extreme faintness of the telluric lines during a keen frost; even with a low sun this seems to be strongly confirmatory of their being due to aqueous vapour.

Photography will enable the position of the lines visible in the spectrum of the setting sun to be registered as never would have been possible by the laborious method pursued by M. Thollon; their number seems to increase almost indefinitely as the last limb of the sun sinks over a sea horizon. I have on more than one occasion watched the spectrum of the setting sun at sea with a hand spectroscope, and been reminded of the spectrum of a red star, so entirely does the character of the solar spectrum change owing to the added lines and absorption bands.

Section 3, the E group and adjacent lines. Peculiar interest attached to this group, as on the original negatives not only is the E line divided but also the line at wave-length 5264·4, which is twice as close. Both Angström and Kirchoff give this as being the position of a line common to both iron and calcium; but the duplicity of the line in the solar spectrum suggests that possibly the two elements have not even a vibration in common. It has been customary with some speculative physicists to speak of two elements having a common line in their spectra, as if they were thus shown to be not elementary, and were proved to be built up of still more elementary substances, one of which was thus proved to be common to both of them; but the fact that some parts of two molecules have a common period of swing, no more proves them to be identical than a violin is proved to be identical with a trombone because they are both capable of sounding the same note. It should rather be taken as proof that under particular circumstances there is some common ratio in the architecture of the two molecules, or some similar ratio between stresses and distances, which may be altogether different in the two molecules—but there is no such thing in spectroscopic analysis as proving two lines to be identical; a higher dispersion may at any time show that lines which were believed to be identical are really distinct. In this case there is only a difference of wave-length between the two lines which amounts to $\frac{1}{50000}$ths of the whole wave-length.

The duplicity of K. 1474 is another case in point. It is shown distinctly double in the plate, Section 3, at wave-length 5316·9. It was at first spoken of as an iron line, and theories were formed as to the existence of this one iron line in the corona. Prof. Young first saw that the dark line was double in the solar spectrum; and afterwards, during the eclipse of 1870, identified the coronal line with the chromosphere line, which he had already identified with the component of 1474 that does not belong to the iron spectrum. b_3 is another case in point; on the maps of Angström and Kirchoff it is marked as a line common to magnesium and iron, but it is now seen to be a double line.

Section 4, the G region. This is a most difficult region of the spectrum to draw, owing to the vast number of lines it contains; one can hardly put a pin's point down anywhere than on a line dark or faint, broad or narrow, but the photographic plate registers them all just as readily

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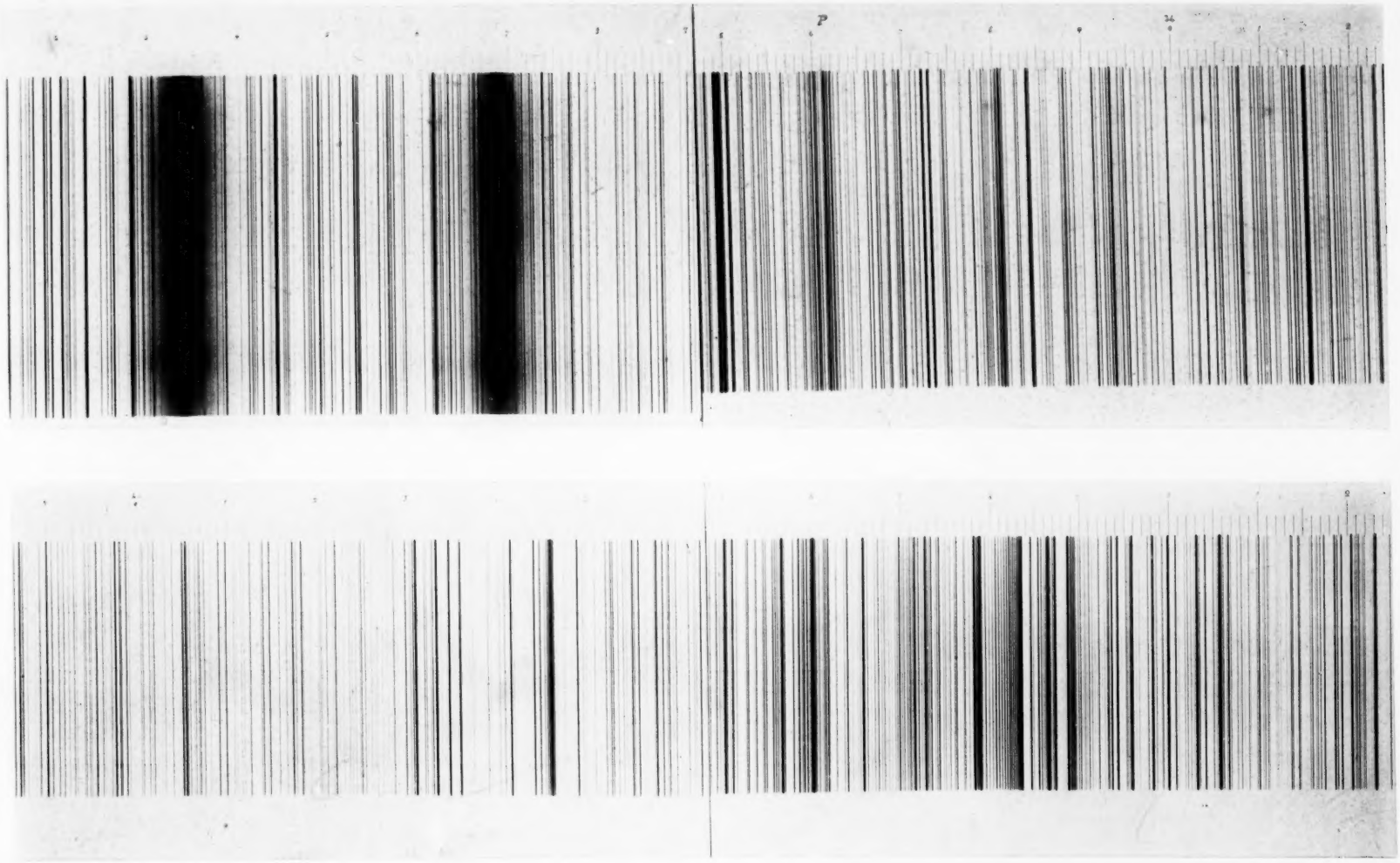
6. The K and H Lines, formerly known as H_1 and H_2.
Region wave-length 3910 to 3990 tenth-metres.

8. Region between P and O.
Wave-length 3350 to 3425 tenth-metres.



5. Region between H and h.
Wave-length 3390 to 4060 tenth-metres.

7. Region L and K.
Wave-length 3850 to 3925 tenth-metres.

One tenth-metre equals one ten-thousand-millionth of a metre.

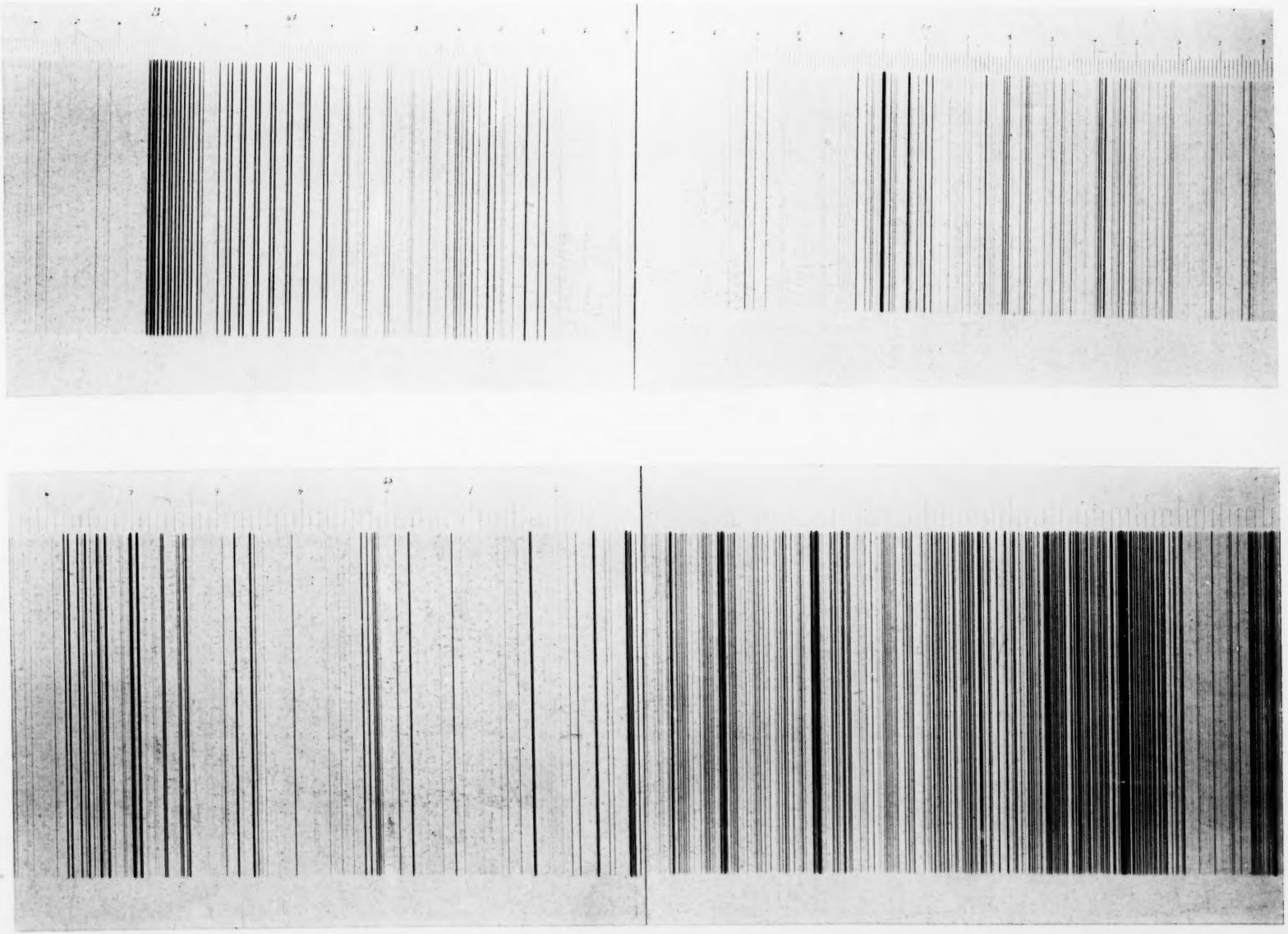
PARTS OF PHOTOGRAPHIC MAP OF THE NORMAL SOLAR SPECTRUM MADE BY MR. GEORGE HIGGS.

Direct Photo Eng. Co., Limited, 9, Barnsbury Park, N.

1. Great B Group.
Wave-length 6830 to 6980 tenth-metres.

2. The D and Rain-band Group.
Wave-length 5830 to 5980 tenth-metres

One tenth-metre equals one ten-thousand-millionth of a metre.



3. The E Group and 1474 Lines.
Wave-length 5255 to 5330 tenth-metres.

4. Great G Group.
Wave-length 4230 to 4330 tenth-metres.

PARTS OF PHOTOGRAPHIC MAP OF THE NORMAL SOLAR SPECTRUM MADE BY MR. GEORGE HIGGS.

as it registers the appearance of a region poor in lines. There are three or four narrow spaces in this region of the spectrum which look very like bright lines, and it is difficult to convince oneself that they are not brighter than the rest of the background of the spectrum. I am inclined to agree with Dr. Draper that they are actually brighter spaces in the solar spectrum. There are similar bright spaces in the portion of the spectrum shown in Section 7, near to wave-lengths 3884 and 3888.

The nebulous K and H lines, shown in Section 6, are seen to contain a great number of fine lines which are, however, not symmetrically arranged with respect to the centres of the nebulous bands, and therefore probably cannot be regarded as forming a group associated with the hazy lines on which they happen to lie.

The concave grating used by Mr. Higgs is mounted on one side of a circular table, ten feet two inches in diameter. The sensitive plate on which the normal spectrum is thrown is at the opposite extremity of the diameter of the circular table, and the slit is also mounted on the circumference of the circle, in a position with respect to the grating and sensitive plate which varies according to the order of spectrum which is being photographed. The light of the sun is thrown by a heliostat upon the slit. In most positions of the slit more than one order of spectrum falls upon the plate at the same time, the red region, say, overlapping the violet region of another order. In order to obtain a photograph of one of these spectra, say the lines in the red region, the blue light of the other spectrum is cut out by a bath of absorbing liquid placed in front of the slit. When all but the one spectrum is eliminated, the actinic action at one end of the plate will be sometimes as much as fifty times as great as that at the other end; and if both ends of the plate were exposed for the same period, the one end of the spectrum would be greatly over-exposed when the lines at the other end were just beginning to register themselves on the plate. To avoid this difficulty Mr. Higgs makes use of shutters within the camera, moved by clockwork, which can be adjusted so that different portions of the plate are exposed for different periods. Possibly on another occasion I shall be able to give further details as to some of the ingenious appliances which Mr. Higgs has devised to facilitate his work.

Letters.

[The Editor does not hold himself responsible for the opinions or statements of correspondents.]

To the Editor of KNOWLEDGE.

SIR,—The following note on "Recurring Decimals" of the form $abc\ldots ka_1b_1c_1\ldots k_1$ where $a+a_1=b+b_1=$ &c. $=r-1_1$ if r = the radix; consisting of two equal periods of n figures, P & Q supplementary to each other—may interest your readers.

1. Let $S=\cdot P\dot{Q}$

$\therefore \quad r^n\ S=P\cdot Q\dot{P}$

$\therefore (r^n+1)\ S=P+1$

$$S=\frac{P+1}{r^n+1}$$

thus $\cdot 142\ 857=\frac{142+1}{10^3+1}=\frac{143}{1001}=\frac{1}{7}$

All fractions whose denominators are divisors of r^n+1 belong to this class;

thus $\frac{1}{10^1+1}=\frac{1}{11}=\cdot 0\dot{9}$

$\frac{1}{10^2+1}=\frac{1}{101}=\cdot 00\,99\dot{}$

The divisors of $10^3+1=1001$, are 7, 11, 13, so that $\frac{1}{7}$, $\frac{1}{13}$, &c., belong to this class, &c.

2. All fractions of the form $\frac{1}{nr-1}$

(1) belong to the above;
(2) the recurring figures can be immediately obtained by multiplying from the end by n;
(3) or by dividing from the beginning by n.

These methods were first pointed out by me in *Nature* for 1878, page 291.

Thus $\frac{1}{19}=.052631578\ 947368421$

and can be at once written down

(1) by multiplying by 2 from the end, the last figure being unity;
(2) by dividing by 2 from the beginning on a similar plan;
(3) or by writing down one period by either of the above ways, and adding the supplementary period.

Knowing $\frac{1}{nr-1}$ we can at once write down the period for $\frac{nr-2}{nr-1}$ by subtracting the former from unity or 9 in our scale.

Thus	$\frac{1}{19}=\cdot 052631578$	947368421
$\therefore$	$\frac{18}{19}=\cdot 947368421$	052631578

We observe here that the supplementary period simply comes first, and, its last figure being unity, we are able to perform the Hibernian feat of *beginning* in the *middle* and working towards the left by multiplying by 2, or towards the right by dividing by 2. R. CHARTRES.

To the Editor of KNOWLEDGE.

SIR,—Your article in KNOWLEDGE for May is just to hand, and in regard to your quotation of my remark (p. 130) that "many of the rays join two volcanic centres," I think you will see that this is correct. Neison, on p. 77, says "in some cases the rays end sharply at a crater, or ring plain." On p. 314 he says: "On the west many light streaks unite the two systems of Copernicus and Kepler, . . . north-east a great bundle of long, thin, very intense streaks unite the two systems of Aristarchus and Kepler," and this feature is referred to in other places. I should hardly have risked such an important "statement" on my own responsibility.

With regard to rays being due to snow *deposited* from air "*cooled by radiation*," after issuing from long radial fissures, might I point out that air—warm or cold—could hardly issue into such a void so gradually as is implied; such an issue would, almost necessarily, be of an explosive nature.

To this I attribute the formation of the nimbi or bright (often rayed) patches around some craters, see p. 24 of my theory—*i.e.* to the discharge at rare intervals of some air or gases charged with aqueous vapour.

The fact that craterlets, crater cones, and rows of confluent craters are so generally seen on the line of clefts, is a fairly good proof that, if due to exhalation of aqueous vapour, they must pass down to the warmer and moister *substrata*.

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In conclusion, may I point out that the narrow band of increased brightness, round the limb, so well seen in the photographic prints in KNOWLEDGE of October last, would more probably be due to light reflected to us from cliffs than hill-tops. If the hills were flat-topped especially, the light would (at full moon) be reflected from, and not towards, our earth; and it is because this band is so well seen at full moon that I take it the light comes from cliff-faces, or the *slopes* of hill-tops.

Sibsagar, Asam, India, S. E. PEAL.
July 21, 1890.

[It certainly cannot be said that most of the rays join volcanic centres—Mr. Peal's theory would not apply unless they all did. As to the air only issuing from deep clefts in the soil by reason of underground explosions, one would expect to find convection currents constantly in action bringing warm air to the surface over a vertical vent when the walls at the bottom are warm compared with the rocks above. I agree with Mr. Peal as to the sides of the mountains being visible on the moon's limb, and did not intend to suggest that we looked vertically down on the mountain-tops. The narrow band of brightness seen on the moon's limb shows that the higher parts of the mountains with their sloping sides and cliffs are all whiter than the lower ground. This must either be due to their natural colour or to snow. The snow-caps would no doubt descend in the form of glaciers, as they do upon the earth, leaving the mountain-tops bare, if the snow were not continually replaced by aqueous vapour carried upward in the thin lunar atmosphere.—A. C. R.]

To the Editor of KNOWLEDGE.

DEAR SIR,—Is the following of sufficient general interest to warrant an answer in your columns? Supposing a fast and a slow ball to be hit in cricket with equal force, and in exactly similar manner, back over the bowler's head, which will travel farther? I have maintained that as there is a greater impetus to be overcome before the fast ball commences its return journey, the distance it is carried will be less than in the case of the slow ball; but I can find hardly anyone to agree with me, my opponents generally basing their opinions on "observation." Some of them attempt to account for what they believe they have observed, by remarking that the elasticity of the bat would drive back a fast ball farther than a slow one. I should like to have a disinterested theoretical opinion about it, if you do not consider it outside the scope of your magazine. Apologising for troubling you,

I am Sir, yours faithfully,
St. Leonard's. W. W. E.

["W. W. E." does not give all the data that are necessary to answer his question. Everybody is familiar with the fact that a slow ball rebounds to a less height from a floor than a ball thrown down more rapidly, and the fact is not affected by the floor being elastic as well as the ball. Consequently, if the ball were "blocked" by the batsman firmly holding the end of his bat on the ground, the fast ball would return fastest, and the velocity of return would bear a constant ratio (depending on the elasticity of the bat and the elasticity of the ball) to the velocity with which the ball was delivered. When the ball is struck in the usual manner, the velocity of the bat will be most reduced by the fast ball at the instant when the ball is reduced to rest, as well as at the instant when the ball leaves the bat, if there is no muscular force applied to the bat in the interval; but we must know the weight of the bat as compared with the weight of the ball, as well as the way in which the force of the batsman's arm is applied—as he continues to urge the bat forward after the ball has been reduced to rest—before we could attempt to calculate the velocity of the return of the fast ball, as compared with the return velocity of the slow ball. It is evident that a fast ball would be returned more rapidly, from a pendulum weighing some tons, than a slow ball which hit the pendulum in exactly the same part of its swing. But from a pendulum so light as to be nearly reduced to rest by the blow of the fast ball, the slower ball would return most swiftly.—A. C. R.]

Messrs. Longman and Co. wish me to state that the publication of the parts of the *Old and New Astronomy* has not come to an end. Part XI. has occupied me much longer than I expected. I am, however, now at work upon the last sheet of it, and hope to pass it for press in the course of the next week. Part XII. and the Index will, I hope, follow shortly.

We learn from a Californian paper, which Mrs. Proctor has forwarded to us, that some citizens of San Diego propose to found a Proctor Memorial Observatory on the summit of Mount San Miguel, a mountain peak overlooking the town of San Diego. Mrs. Proctor writes to us from the Lick Observatory, where she has been stopping as a guest of Mr. Burnham, after completing a successful lecturing tour in California.

A star showing a bright line spectrum which differs from that of any other star showing bright lines has been discovered at Harvard. It is of the 9·3 magnitude, and its position is R.A. 19h. 31·9m., decl. + 30° 19′.

Notices of Books.

A Handbook of Descriptive and Practical Astronomy, Vols. II. and III. By GEORGE F. CHAMBERS, F.R.A.S., Oxford Clarendon Press. Volume II. deals with astronomical instruments—the telescope and its accessories, telescopic stands, transit instruments, and the forms of observatories. A valuable history of spectroscopic astronomy, which has been revised by Mr. Maunder, occupies nearly a hundred pages. Volume III. is devoted to stellar astronomy, and contains a very great number of valuable lists and references. Mr. Chambers has always made the compilation of such lists and catalogues a feature of his books; and they greatly add to the value of this book as a work of reference. His list of large achromatic telescopes, his bibliography of star catalogues, and his chronology of astronomical discoveries, in the second volume, are all very valuable. Unfortunately the printers have made some strange mistakes in printing the third volume, having intermixed the catalogue of Red Stars and the catalogue of Binary Stars in a way which must be very annoying to the author. Part of the catalogue of Binary Stars seems to have been left out, and part intermixed with the Red Star chapter. Page 321 is followed on the other side of the leaf by page 290.

Birds' Nests, Eggs, and Egg Collecting. By R. KEARTON. (Cassell & Co.) This is a most attractive little book, clearly printed, and very tastefully got up. Of the plates it is impossible to speak too highly; they are models of colour printing, and are both artistic and natural. There are sixteen of them, each representing nine eggs, so that about half the British species are figured. In his introductory remarks, Mr. Kearton teaches the egg collector to

pursue his hobby thoughtfully, keeping one eye on the egg and another on its surroundings, that their mutual bearings may be noted, and the causes of peculiarities, if possible, traced out. Under such circumstances, it is the more to be regretted that no attempt has been made at classification, the eggs being described simply as they occur in the plates, where they are arranged with a view to artistic effect rather than to affinity. The descriptions might easily have been arranged according to some system of classification, and we venture to think that thereby a really beautiful book would have been made considerably more valuable.

British Fossils, and where to seek them. By JOSEPH W. WILLIAMS. (Swan, Sonnenschein & Co.) This new volume of the marvellously cheap "Young Collector Series," maintains the reputation its predecessors have deservedly gained, and well supplies a want that every tyro must often have felt. "What to look for, and where to look"—the two burning questions that perplex the amateur fossil-hunter when he sallies forth, hammer and bag in hand, to explore a new district—these form Mr. Williams' text, and in terse language he endeavours to solve the difficulties, by pointing out where each formation is best developed, and detailing the characteristic fossils of each. He has thus produced a *multum in parvo*, which no young collector can afford to be without, and which should prove a valuable pocket companion in the field. The illustrations are numerous and good, especially of the fossils of the older formations. Workers in the Tertiaries would probably have been grateful for a few more figures of the abundant Mollusca of the period.

The Story of Chemistry. By HAROLD W. PICTON, B.Sc. (Wm. Isbister.) In this useful and compendious handbook we have a clear and simple account of the progress of chemical research from the times of the alchemists to the present day. Mr. Picton wisely makes no assumption of initial technical knowledge on the part of those whom he addresses, and his book is, in the main, as intelligible to the general reader as to the student or the specialist. It is in itself a wonderfully fascinating tale, this, of the long struggle through the centuries between the human intellect and Dame Nature, till, after many unfruitful efforts, her secrets were finally, one by one, wrung from her grasp. But one of the most attractive features of the "story," as the author tells it, is the judicious proportion and the apt connection in which the biographical element has been introduced. To the ordinary student, the great discoverers in chemical science are too often little more than names; Mr. Picton has invested them with a living personality; he has not been so intent on detailing the gradual growth of the solid mass of facts which form the modern chemist's inheritance as to leave out of sight the human agencies by which the triumphs were achieved. We are shown what sort of men they were whose names figure so largely in ordinary text-books of chemistry, and in consequence the additional interest of life is imparted to the science which deals with dull, dead matter. Those who are puzzled by the interdependence of the facts of chemistry, and have found it difficult therefore to realise how the foundations of knowledge were laid down, will appreciate the service Mr. Picton has rendered in clearly detailing, and yet compressing within moderate limits, the story of the progress of discovery and the course by which the essentials of chemical truth were established.

Museums and Art Galleries. By THOMAS GREENWOOD, F.R.G.S. (Simpkin, Marshall & Co.) This companion volume to the author's *Free Public Libraries* ought to be in the hands of all who are practically concerned with the advancement of the Museum and Art Gallery movement, and will, we trust, help to stimulate public interest in these invaluable adjuncts of the Public Library. With commendable industry, Mr. Greenwood has compiled a mass of information about the various Museums and Art Galleries of all characters scattered throughout the United Kingdom, as well as the chief ones on the Continent and in America. Some additional chapters are devoted to such very important branches of the subject as the "Classification and Arrangement of Objects," "Sunday Opening," "Museum Lectures," &c. We would specially call attention to the latter subject. There can be no doubt that the utility of a Museum or Art Gallery is immensely increased by the establishment in connection with it of series of good lectures on different groups of the objects exhibited; and provided the two main difficulties of suitable lecturers and necessary funds can be got over, no institution of the kind should be considered complete without some such provision. The author urges the adoption, whenever practicable, of the "Public Libraries Act," arguing that the only remedy for the neglect under which most of them suffer, and the unsatisfactory condition under which they exist, is to be found in adopting the Act, and making them rate-supported. But he neglects the educational effect of the interest called forth in those who subscribe and associate themselves together for the management of such institutions. He is perhaps inclined to over-estimate the ethical influence of Museums and Art Galleries on the holiday-making section of the community. It would appear to be sounder policy to advocate their establishment as a means of intellectual culture for a class which, though very important to the community, does not generally look to the rates for help, and had better not be encouraged to do so unless it is willing to accept the control by the State, as well as State-aid, with its attendant red-tape and stereotyped methods.

Northern 'Ajlûn, "within the Decapolis." By G. SCHUMACHER, C.E. (A. P. Watt.) Herr Schumacher has already made his mark as a painstaking and able explorer by the work he has done as a member of the staff of the "Palestine Exploration Fund." His operations have been carried on in the northern part of the "country beyond Jordan," and several memoirs detailing the results have, during the last few years, been published by the "Fund." The present modest little volume forms a further contribution to the topography and archæology of that region, issued under the same auspices. To none but Palestinian experts will the title be likely to convey much information—a matter of no great consequence, however, as the book is evidently intended rather for students of the antiquities and ancient history of the Holy Land than for the reading public generally. Under the name "Northern 'Ajlûn," Herr Schumacher includes a small district of about 220 square miles in extent, lying S.E. of the sea of Galilee, and immediately south of the river Yarmuk, and therefore just beyond the limits of the region which has achieved notoriety as the site of the "Giant Cities of Bashan." It is interesting chiefly as being part of the Decapolis of Biblical times, and as containing the township of Umm Keis, which is believed to be on the site of the ancient Gadara. A detailed description of the ruins in this neighbourhood is given, showing the situation and form, so far as can be ascertained, of theatres, temples, and tombs belonging to the city which Josephus describes as "a place of strength, containing many rich citizens." A plan of the site is added, and many neat and careful drawings show plans and details of the ruins, accompanied in every case by all needful measurements. The

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next most important group of ruins explored was at Beit Râs, which, correcting a previous identification, Herr Schumacher is inclined to think may represent the ancient Capitolias. The chief material of which the ruins are composed in all parts is the soft friable limestone of the district; hence the remains are not in such good preservation as the hard basaltic structures of Bashan. At Irbid (Arbela) large numbers of dolmens were discovered, several of which are figured. By clearing away the soil from the interior of some, masses of ashes and decayed remains of bones were revealed, apparently suggesting that these curious structures were used sometimes as places of sepulture. A well-filled and plainly printed map, and notes as to the present condition, population, and industries of the district are further features of interest, adding to the value of what appears to be a carefully executed piece of work.

THE MARINER'S COMPASS: ITS ERRORS AND THEIR CAUSES.

By R. BEYNON.

THE constancy of the mariner's compass in indicating a north and south direction has long furnished poets with an emblem of undying devotion and fixedness of affection. Modern science and research, however, go far to prove that under certain conditions the compass is far from being an infallible guide. It is true that these deviations of the needle are all consequent upon the operation of the natural laws of magnetic attraction and repulsion; but in our present state of knowledge the exact part played by these disturbing forces is not accurately known.

Since the adoption of iron and steel as shipbuilding materials, the difficulty of guarding against local attraction has been vastly increased. Such importance is now attached to these errors of the compass that it is regarded as an axiom, amongst navigators, "never to regard the compass as infallible, but only as a means of carrying the ship safely from one observation to another."

When an iron or steel ship is in process of building, a definite magnetic character is impressed upon her—*i.e.* the ship, as a whole, becomes a gigantic magnet. This sub-permanent magnetism, as it is called, is at first very erratic and uncertain in its action; but twelve or fifteen months' voyaging serves to rob it of its unstable character, and render it constant. But this is not the only needle-disturbing influence that the compass adjuster has to correct. The magnetic influence of the earth will naturally induce in a ship a magnetism that will, in north latitudes, have its north-seeking pole at that part of the ship nearest to the north magnetic pole of the earth. From this it follows that the upper parts of vertical iron, such as the upper edges of the funnel, ventilators, &c., being farthest from the magnetic lines of force, will be charged with south-seeking magnetism, and will, when the ship is north of the magnetic equator, attract the north-pointing end of the needle. At the magnetic equator itself the effect of vertical iron will be neutralised by the equal attractive influences of the north and south magnetic poles of the earth. South of the equator, however, vertical iron will be charged with induced magnetism that will repel the north-seeking end of the needle. The influence of this vertical iron is the great enemy to thorough reliability of the compass, as its effects vary with the latitude. The deviation caused by horizontal iron—or quadrantal deviation, as it is termed, from its effects being different in different quadrants—does not present the same difficulties to the corrector as does vertical iron. The quadrantal error is nearly constant, no matter what the latitude; so that when once it is properly corrected, that correction suffices.

An almost perfect instrument for compensating quadrantal deviation has been invented by Chevalier Peichl, of the Austro-Hungarian Navy. It consists of a number of soft iron rods disposed round the compass, so that their interior ends form an ellipse, of which the major axis is parallel to the keel. Above this system of rods is another which may be moved independently of the other. The action of this corrector is due to the induction of the compass needles on the soft iron rods. An index and scale provides for the varying of this inducted power consequent upon change of latitude. The sub-permanent magnetism of the ship and the effect of vertical and horizontal iron are pretty thoroughly compensated for when the vessel's compasses are adjusted. The principle involved is merely an adaptation of the old law, that the only method of destroying the effect of one magnetic disturbing force is to introduce another magnetic force which follows the same laws and has the same magnitude, but always acts in the opposite direction.

There yet remain many accidental compass-disturbing influences that require the utmost watchfulness on the part of navigators. A consensus of opinion would appear to obtain among practical men, that a compass elevated on a pole, to an altitude above the vessel's main deck equal to her beam, is free from the disturbing influences of the magnetism of the vessel's hull. Such a compass, when corrected for the vertical iron of the funnel, &c., forms a useful check upon the standard compasses placed upon the deck or bridge. Even with this safeguard, however, recent research shows that the compass corrections cannot be absolutely relied on. When a ship steers upon the same course for any length of time, it is found that a certain magnetism is induced in the vessel as a whole. This "transient-induced" magnetism, as it is called, differs from the sub-permanent magnetism which the vessel acquired while upon the stocks or in the building dock, in that its character is stable only so long as the vessel continues upon that course. A few hours' steaming in another direction serves either to annihilate or to materially change its nature. We have seen that the sub-permanent magnetism is constant, owing, no doubt, to the fact that the hammering of the plates and rivets transformed what was originally "transient-induced" into stable magnetism. This transient force may be induced in a vessel by her lying in one position in dock for a considerable length of time. All attempts to provide an adequate corrector for this disturbing influence have hitherto proved abortive, and the only safeguard of the navigator is constant observation and careful notation of the results for present and future use. "Transient-induced" magnetism dies away completely twenty-four hours after altering the heading of the ship. Probably the error of the compass thus caused is accountable for the apparently inexplicable stranding of vessels that leave port when thickness of weather precludes the possibility of observing landmarks, &c. It will be readily seen that the carrying of mineral cargoes must occasionally have a great influence upon the directive powers of the needle; and it is in such cases as this that the true value of a pole compass, which is practically removed from the chaos of disturbing magnetic forces that obtain on the lower part of the ship, is seen. When the custom of carrying large consignments of crude petroleum first came into practice, many shipmasters averred that the mineral matter con-

tained in the oil was a prolific source of compass error. Subsequent experience, however, has neither disproved nor substantiated this opinion. Now that the petroleum trade has assumed such enormous developments, this is a phase of the subject which requires investigation, and can only be solved by mariners recording in detail the conduct of the compasses when placed in close juxtaposition with such a cargo. The influence of land masses, when vessels are engaged in cruising in close proximity to the coast, is undoubtedly a *bonâ fide* source of compass deviation, the importance of which cannot be over estimated. Many rocks contain large masses of iron in one form or another which must exercise an attractive or repellent influence upon the compass needle brought near them. The results of many recorded observations show that magnetic rocks in the northern hemisphere attract the north-seeking end of the needle, while south of the magnetic equator the contrary effect is produced. Red sandstones, as containing ferruginous matter in the form of a colouring oxide, produce considerable deflection upon the needle brought near them. But it may be argued that it is very rarely that a ship would approach so near a shore as to come within the zone of magnetic disturbance. This is true. But at the same time the ship, while sufficiently distant from the land to preserve her compasses intact from deflection caused by horizontal attraction or repulsion, may yet be separated vertically, by but a few fathoms, from rocks of the same nature. Perhaps the most striking recorded example of deflection caused by rocks in the sea-bed over which a vessel was sailing is that of H.M.S. surveying vessel *Meda*. This ship, while engaged in surveying on the north coast of Australia near Cossack, reported that when three miles off the shore and in eight fathoms of water her compass was steadily deflected 30° for a period of fifteen minutes, during which time she sailed over one mile. The variation marked down for the east coast of Madagascar is 11° W. to 12° W. But the French men-of-war, which are frequently cruising in these waters, find that the variation near the shore at St. Mary's Isle is only 6° or 7° W. The attraction of the north-seeking end of the compass by the magnetic rocks at the bottom is held accountable for the 5° of alteration. Similar results have been recorded of places upon the coasts of New Zealand.* To many sea-going people this will no doubt be a revelation, for it is only very recently that the influence of rocks under the bottom of a ship has been credited with the power of causing needle deviation. What the exact relationship is between vertical magnetic attraction and the horizontal deflection consequent upon it, is at present undetermined. But further researches in the matter will be watched with the keenest interest by the nautical profession as well as the scientific public.

Another alleged cause of compass deviation is fog. A large percentage of the strandings which occur during fogs are ascribed to unknown errors in the compass. A careful perusal of these cases, however, establishes the important fact that no authentic case of fog disturbance has ever been adduced except to account for an apparent mistake in reckoning. Observations taken to test this theory show there is little or no foundation for it. The most sensitive instruments at Kew show no alteration in their directive power during the densest fogs. Staff-Commander Creak, superintendent of compasses at the Admiralty, expresses the opinion that bad steering in all probability accounts for the compass deviation attributed to fog. When a ship is in sight of land, the objects visible on shore form points of reference by which any looseness of steering can be compensated. Should a fog come on, and the same careless hand remain at the wheel, it is possible that now, when the correcting objects on shore are no longer visible, a falling off of the vessel from her course may result in her stranding. It is just possible, also, that in the case of some of the strandings attributed to compass error caused by fog, the real cause of the deviation may be magnetic rocks lying in close proximity to the vessel.

Some of the causes of compass errors would be amusing were they not productive of the most disastrous consequences. Some little time ago a vessel was wrecked in the Channel during thick weather. It transpired, at the inquiry into her loss, that when the master made the observation by which the fatal course was fixed that sent the vessel ashore, the man at the wheel was wearing a magnetic belt. It was consequently assumed that the compass needle was deflected by "Jack's belt," and that when he left the wheel the deflection disappeared, and the compass, having assumed its normal condition, led the ship on to destruction. The metallic ribs of an umbrella thoughtlessly placed near the standard compass by a passenger have been known to produce a deviation of the needle, and consequent erratic steering.

The two accidental causes of error alluded to above point their own moral. Officers and crew, or even passengers, may carry about their persons some hidden source of magnetic force which, if taken near to the steering compass, will undoubtedly influence it, possibly without the error being detected for the time being. It is evident that ships' compasses will have to be jealously guarded from any possible deflection from these hidden influences.

Now that electricity is coming into such general use on board steamships, too much care cannot be taken to procure for the compass absolute immunity from its influence. With a perfect insulation there is no danger; but many cases confirm the opinion that where the installation is carried out on unscientific principles, or where the insulation is imperfect, the compasses may be rendered absolutely dangerous.

Speaking of this phase of the subject, Captain Creak has laid it down as an axiom that the dynamos employed should be placed at least 35 feet from the compasses. On board the *Euphrates* the compass, though 40 feet away, was affected by the polarity of an Edison machine. Both poles of the machine should be at an equal distance from the compass, while the lead and return wires should be placed as near together as possible and carefully insulated. A most interesting example of what may occur with improper installation is evidenced by experiment on H.M.S. *Royalist*. One of the wires from a dynamo was made to pass under the standard compass at a distance of some 13 feet. The return wire was separated from it by some 5 feet. The passage of the electric current along the wire caused a deflection of some 8°, which increased with the strengthening of the current. The compass in this way was transformed into a galvanometer, registering any variation in the strength of the current with the utmost exactness. Vessels whose electric lighting system provides but a single wire lead and utilizes the hull as return, very materially increase the risk they run of having their compasses thrown into error.

In conclusion, it must not be lost sight of that each ship possesses an individual magnetic character of her own, and

* There is a similar area of magnetic deflection in the Adriatic which was surveyed at the request of Father Secchi. It seems probable that such local disturbances are due to the action of hot springs or volcanic vents, which affect rocks containing magnetic oxide of iron or other magnetic matter and cause them to become magnetic radially with respect to the source of heat. In other situations magnetic strata take up the induced magnetism of the earth, and would not sensibly disturb the direction of the compass.—A. C. R.

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it is only by a scientific study of this character that her compasses can be guarded against the influence of local magnetic action. As the constituents of this action are to a large extent variable, it behoves the mariner to be ever on the watch for causes which may interfere with the reliability of his "directive index." With the use of iron for shipbuilding, and the introduction of electric lighting on board ships, the necessity for increased watchfulness is considerably augmented. With regard to the external disturbing forces little danger is to be anticipated from magnetic rocks during the day; but at night, shipmasters who love to shave corners would do well to ponder on the instances of the vertical attraction of rocks adduced above.

HARMLESS PARASITES AND UNINVITED COMPANIONS.—II.

By Henry J. Slack, F.G.S., F.R.M.S.

AMONGST the microscopic animals that are apt to swarm upon other creatures, perhaps the commonest are members of the vorticella or bell polyp family. They are frequently so numerous as to surround their victims like a cloud, and must be a great nuisance to them. In these cases the assailants must be regarded as parasites, though not of the worst sort, as they do not feed upon their landlords.

When an intestinal worm makes its abode in the liver, brain, or muscle of some mammal, the parasitism is of the worst kind, for it destroys living tissue. In a milder set of instances parasitic invaders live like Jonah in the stomachs of their hosts, and nourish themselves upon some of the food the latter collect. This is robbing a neighbour's pantry of part of its contents; but if plenty is left for his own consumption, no great harm is done. The *Holothuridæ*, or sea slugs, that supply microscopists with beautiful objects in the shape of the calcareous wheels, anchors, and curiously perforated plates with which their integuments are beset, also furnish many instances of parasitism. One species affords board and lodging in its stomach to a small eel-like fish (*Donzella*); while others that collect a very liberal commissariat are visited as boarders by prawns and pea-crabs. Beneden tells us that his friend Semper found some of these creatures in the Philippines who were not bad imitations of an hotel furnished with a *table-d'hôte*.

Sea anemones and jelly-fish frequently act as hotel keepers, and Dr. Collingwood found in the China seas a monster of the former kind ten feet in diameter, sheltering in its interior some lively little fish. This is the more curious as these animals are well armed with poison threads, or flexible darts, which they project with considerable penetrating power; and Gosse mentions an instance of a little fish that died in a few minutes in great agony through a momentary contact of its lips with one of these weapons. For full and very interesting particulars of these organs the reader is referred to Gosse's *British Sea Anemones*; but those who visit the seaside with microscopes may easily see some of them by snipping off a little piece of an anemone's tentacle, and viewing it under compression with a high power. One form of these weapons is shown in the sketch copied from Gosse (Fig. 1). The vesicle he calls a *cnida*, and the thread coiled in it an *ecthoreæ*. This the animal was flinging out with lightning velocity and great force.

Whether an anemone that plays the host to little fishes derives any benefit or pleasure from their company we do not know, but if it found them objectionable lodgers it would turn them out. It is often puzzling or impossible to comprehend the human motives that impel to extraordinary actions, and still more so is it to imagine the *why* of many doings of the lower animals. Why, for example, does one species of hermit crab, that has taken the shell of some gasteropod for its dwelling, encourage the cloak anemone (*Adamsia palliata*) to fix itself on the lip of its abode? Lieut.-Col. Stuart-Wortley tells us that the crab offers its companion a share of its food captures, and assists the anemone to move with it when it finds its home too small and takes possession of a larger shell. No species of hermit crab except *Pagurus Prideauxii* forms this curious connection, and the most probable explanation of the partnership is that suggested by Dr. Landsborough, cited by Gosse. He says, in all likelihood they in various ways aid each other. The hermit has strong claws, and while he is feasting on the prey he has caught, many spare crumbs may fall to the share of his gentle-looking companion. But soft and gentle-looking as the anemone may be, she has a hundred hands, and woe be to the wandering wight who comes within reach of one of them, for all the other hands are instantly brought to its aid, and the hermit may soon find that he is more than compensated for the crumbs that fall from his own booty.

Collectors of pond objects often find the fresh-water polyp, and frequently discover it in association with an infusorium, the *Trichodina pediculus*, which can attach itself to its host by a sucker, or run freely over it by means of cilia that do the work of legs. The currents it produces by its ciliary organs must be useful to the polyp, and it is said to act as scavenger and to remove waste matter from its friend's skin. Another infusoria, *Kerona polyporum*, also settles on the polyp, and Kent says that "where the two abound, it may be not unfrequently observed that the *Trichodinæ* mount upon the backs of their companions, and thus utilise them as a man might a horse, for the enjoyment of locomotion, without having to participate in the labour of its production." Like the anemone and the jelly-fish, the polyp has poison threads, and could destroy its visitors if it objected to their presence.

Fig. 1.—Chambered Cnidæ.

A great many other instances might be given of animals boarding together in friendly harmony or actual co-operation. Amongst the crustaceans such partnerships are numerous, and a tiny pea-crab that makes its abode in mussel-shells is evidently welcome to its shelter.

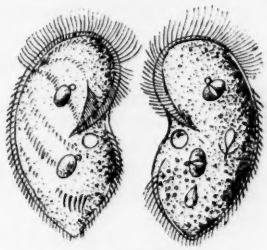
The ancients, Beneden says, noticing the mussel's blindness, thought the crab's sharp eyes enabled it to see by deputy; but a more probable solution of the question is that the crab is a good food-catcher, and the mussel enjoys part of the spoils.

Fishes are visited by numerous animal and vegetable colonists, some harmless and others destructive. In all quarters we find both fellow-boarders and parasites, and it is to be remarked that while the latter have always attracted attention, the former, with few exceptions, have only recently been studied as they deserve.

Fig. 1, after Gosse, represents a very elaborate but "most generally distributed form of *Chambered Cnidæ*"; the vesicles are about ·004 inch long, and in greatest diameter ·0005 inch. Inside the vesicle is a slender, lozenge-shaped chamber, from which proceeds a very long convoluted tube, often from twenty to forty times the length of the *Cnida*. Gosse describes the protrusion of the poison-thread as beginning by a nipple-shaped wart from the anterior extremity, and often proceeding slowly till it

has attained a length of about twice its own diameter, and then darting forth with lightning rapidity. At this instant he said he had in many instances "heard a distinct crack." The writer believes this to have been a delusion. It often occurs in watching the jaws of a large Brachion rotifer, and similar apparatus. A movement which if performed by a mechanism large enough to affect our hearing would make a crack or snap-like noise, is readily imagined to do so when the eye watches a magnified image under the microscope. There are many much simpler poison-threads

FIG. 2.
TRICHODINA PEDICULUS.



FIGS. 3 AND 4.
KERONA POLYPORUM.

than that in the figure. Those in the polyp are far less elaborate but instantly effectual.

Fig. 2 represents *Trichodina pediculus* seen from above in full face. Besides delicate cilia, it has a wreath of horny *denticles*, or little teeth. A side view, when it runs about, shows it as a squat cylinder. Its skin is very flexible, and it can assume various shapes, disc-like, conical, hour-glass, &c.

Figs. 3 and 4, *Kerona polyporum*, ventral and dorsal aspects. It belongs to the *Hypotricha*, which have × 200 thin locomotive cilia on the ventral surface only. It has not, like the *Trichodina*, the power of changing its shape. It is a greedy animal, eating both animals and vegetables, but it abstains from feeding upon its host the polyp.

THE FACE OF THE SKY FOR SEPTEMBER.

BY HERBERT SADLER, F.R.A.S.

THE abnormal paucity of sun-spots still continues. Conveniently observable minima of Algol occur at 6h. 12m. P.M. on the 1st; 11h. 4m. P.M. on the 18th; and 7h. 52m. P.M. on the 21st. Mercury is an evening star during the first half of the month; but is very badly situated for observation, owing to his proximity to the sun. As the interval between the setting of the sun and planet does not exceed half-an-hour throughout the month, any details would be useless. He is at his greatest eastern elongation (27°) on the 3rd, and is in inferior conjunction on the 29th.

Venus is an evening star, but is not well situated for observation owing to her southern declination. She sets on the 1st at 7h. 59m. P.M., 1h. 13m. after the sun, with a southern declination of $10\frac{1}{2}°$, and an apparent diameter of $19\frac{3}{4}''$. On the 30th she sets at 6h. 44m. P.M., 1h. 5m. after the sun, with a southern declination of 22° 20′, and an apparent diameter of $26\frac{1}{2}''$. About the middle of September she appears as a moon about her last quarter; and is at her greatest eastern elongation ($46\frac{1}{2}°$) on the 24th. During the month she passes from Virgo into Libra, but without approaching any conspicuous naked-eye star. Mars is an evening star, and our remarks in last month's "Face of the Sky," as to his telescopic aspect, will, unfortunately for the amateur, rather gain than lose in strength. The planet sets on the 1st at 9h. 5m. P.M., with a southern declination of $25\frac{3}{4}°$, and an apparent diameter of 11·1″. On the 30th he sets at 9h. 17m. P.M., with a southern declination of 25° 55′, and an apparent diameter of $9\frac{1}{4}''$. At the latter date his brightness is only about one quarter of what it was at opposition, and about $\frac{85}{100}$ of the disc will be hidden from view. Mars is in quadrature with the sun on the 21st, and passes during the month from Ophiuchus into Sagittarius, but without approaching any bright star very closely.

Jupiter is an evening star, rising on the 1st at 5h. 26m. P.M., with a southern declination of 20° 10′, and an apparent equatorial diameter of $46\frac{1}{2}''$. On the 30th he rises at 3h. 28m. P.M., with a southern declination of 20° 26′, and an apparent equatorial diameter of 43·0″. The following phenomena of the satellites occur while the planet is more than 8° above, and the sun 8° below, the horizon. A transit ingress of the first satellite at 0h. 29m. A.M. on the 2nd, an occultation disappearance of the same satellite at 9h. 49m. P.M., and a transit ingress of the third satellite at 11h. 52m. P.M. A transit ingress of the shadow of the first satellite at 7h. 46m. P.M. on the 3rd; a transit egress of the satellite itself at 9h. 16m. P.M., and a transit egress of its shadow at 10h. 6m. P.M. An occultation disappearance of the second satellite at 9h. 10m. P.M. on the 5th. An eclipse reappearance of the third satellite at 8h. 49m. 49s. P.M. on the 6th. A transit egress of the shadow of the second satellite at 8h. 58m. P.M. on the 7th. An occultation disappearance of the first satellite at 11h. 36m. P.M. on the 9th. A transit ingress of the first satellite at 8h. 44m. P.M. on the 10th, a transit ingress of its shadow at 9h. 41m. P.M.; a transit egress of the satellite at 11h. 4m. P.M., and of its shadow one minute after midnight. An eclipse reappearance of the first satellite at 9h. 19m. 40s. P.M. on the 11th. An occultation disappearance of the second satellite at 11h. 31m. P.M. on the 12th. An occultation reappearance of the third satellite at 8h. 51m. P.M. on the 13th, and an eclipse disappearance of the same satellite at 9h. 18m. 41s. P.M. A transit ingress of the shadow of the second satellite at 8h. 40m. P.M. on the 14th; a transit egress of the satellite itself at 9h. 32m. P.M., and of its shadow at 11h. 35m. P.M. A transit ingress of the shadow of the fourth satellite at 7h. 25m. P.M. on the 16th (the shadow crosses the central meridian at 9h. 50m. P.M.). A transit ingress of the first satellite at 10h. 32m. P.M. on the 17th. An occultation disappearance of the first satellite at 7h. 52m. P.M. on the 18th, and an eclipse reappearance of the first satellite at 11h. 14m. 57s. PM. A transit egress of the first satellite at 7h. 20m. P.M. on the 19th, and of its shadow at 8h. 25m PM. An occultation disappearance of the third satellite at 8h. 47m. P.M. on the 20th. A transit ingress of the second satellite at 9h. 2m. P.M. on the 21st, and of its shadow at 11h. 17m. P.M. An eclipse reappearance of the second satellite at 8h. 18m. 11s. P.M. on the 23rd. An egress of the shadow of the third satellite at 6h. 53m. P.M. on the 24th, and an occultation reappearance of the fourth satellite at 9h. 32m. P.M. An occultation disappearance of the first satellite at 9h. 42m. P.M. on the 25th. A transit ingress of the first satellite at 6h. 50m. P.M. on the 26th, a transit ingress of its shadow at 8h. 0m. P.M.; a transit egress of the satellite itself at 9h. 10m. P.M., and of its shadow at 10h. 21m. P.M. An eclipse reappearance of the first satellite at 7h. 39m. 4s. on the 27th. Jupiter describes a very short retrograde path in Capricornus during the month, but does not approach any naked-eye star. He is stationary on the 28th.

Saturn and Uranus are practically invisible. Neptune is an evening star, rising on the 1st at 9h. 43m. P.M.,

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with a northern declination of 19° 51′, and an apparent diameter of 2½″, the planet appearing as a small 8th magnitude star. On the 30th he rises at 7h. 50m. P.M., with a northern declination of 19° 49′. He describes an excessively short retrograde arc to the N.N.W. of ϵ Tauri during the month. A map of his path till the end of the present year is given in the *English Mechanic* for November 15, 1889.

The following places, for every fifth day in September, of the comet discovered by Mr. Denning on July 23rd, are taken from Herr Berberich's ephemeris. They are for midnight, Berlin mean time. The brightness at the time of discovery is taken as unity. The comet will pass its perihelion on September 24th, at a distance from the sun of 123¼ millions of miles, and from the earth of 138½ millions of miles.

		h.	m.	s.	°	′	Brightness.
September	1	15	37	52	+25	14·4	2·21
,,	5	15	41	24	+19	21·5	2·18
,,	10	15	45	53	+12	22·6	2·08
,,	15	15	50	26	+ 5	54·5	1·95
,,	20	15	55	4	− 0	0·2	1·80
,,	25	15	59	46	− 5	21·8	1·60
,,	30	16	4	32	−10	12·3	1·45

The comet thus plunges from Corona Borealis through Serpens and part of Libra into Scorpio. There are no well-marked showers of shooting-stars in September.

The moon enters her last quarter at 3h. 29m. A.M. on the 6th, is new at 7h. 53m. A.M. on the 14th, enters her first quarter at 10h. 5m. P.M. on the 21st, and is full (Harvest Moon) at 1h. 0m. P.M. on the 28th. The 6th magnitude star 64 Ceti will disappear at 10h. 40m. P.M. on the 2nd at an angle of 138° from the vertex, and reappear at 11h. 12m. P.M. at an angle of 202° from the vertex, and the 4½ magnitude star ξ^1 Ceti will make a near approach to the lunar limb at 11h. 53m. P.M. at an angle of 175° from the vertex. On the 3rd at 6h. 32m. A.M. (one hour and eighteen minutes after sunrise) the 7½ magnitude star B.A.C. 741 will make a near approach to the lunar limb at an angle of 58° from the vertex. The 6th magnitude star B.A.C. 1206 will disappear at 9h. 32m. P.M. on the 4th at an angle of 49° from the vertex, and reappear at 10h. 20m. P.M. at an angle of 277° from the vertex. The 6th magnitude star B.A.C. 1240 will disappear at 1h. 14m. A.M. on the 5th, at an angle of 75° from the vertex, and reappear at 2h. 22m. A.M. at an angle of 262°. The 6th magnitude star B.A.C. 1801 will disappear at 11h. 55m. P.M. on the 6th, at an angle of 99° from the vertex, and reappear at 0h. 42m. A.M. on the 7th at an angle of 208° from the vertex. The 6th magnitude star 24 Ophiuchi will disappear at 7h. 56m. P.M. on the 20th at an angle of 120° from the vertex, and reappear at 9h. 3m. P.M. at an angle of 285° from the vertex, the moon having set at Greenwich 15 minutes previously. At 7h. 57m. P.M. on the 21st the 6½ magnitude star 63 Ophiuchi will make a near approach at an angle of 197° from the vertex. At 11h. 33m. P.M. on the 24th the 5½ magnitude star χ Capricorni will make a near approach at an angle of 226° from the vertex. The 4½ magnitude star 30 Piscium will disappear at 10h. 36m. P.M. on the 27th at an angle of 123° from the vertex, and reappear at 11h. 45m. P.M. at an angle of 295°. The 5th magnitude star 33 Piscium will disappear at 0h. 32m. A.M. on the 28th at an angle of 100° from the vertex, and reappear at 1h. 28m. P.M. at an angle of 356°. On the 29th the 6th magnitude star 26 Ceti, which has a lilac-coloured 9th magnitude companion at 16½″ distance, will disappear at 3h. 24m. A.M. at an angle of 146° from the vertex, and reappear at 4h. 28m. A.M. at an angle of 338° from the vertex; at 5h. 42m. A.M. the 6½ magnitude star 29 Ceti will disappear at an angle of 169° from the vertex, and reappear at 6h. 35m. A.M., 36 minutes after sunrise, at an angle of 279; while at 7h. 18m. P.M. the 4½ magnitude star ν Piscium will make a near approach to the lunar limb at an angle of 167° from the vertex.

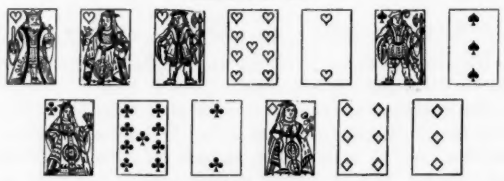
Whist Column.

By W. MONTAGU GATTIE.

DECLINING TO DRAW THE LOSING TRUMP.

WE are indebted to Mr. H. W. Trenchard for the following hand, which occurred recently in actual play, and furnishes an instructive illustration of the good policy, under certain circumstances, of not drawing the losing trump.

HAND No. 13.

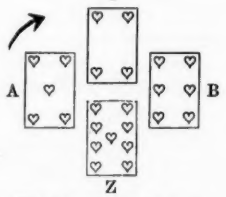


Z's Hand.

Score—2 all. Z turns up the Nine of Hearts.

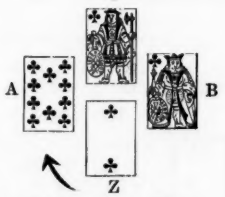
NOTE.—A and B are partners against Y and Z. A has the first lead; Z is the dealer. The card of the leader to each trick is indicated by an arrow.

TRICK 1.



Tricks—AB, 0; YZ, 1.

TRICK 2.

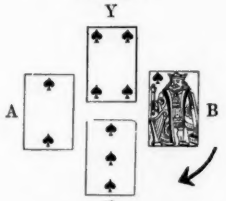


Tricks—AB, 1; YZ, 1.

NOTES.—*Trick* 1.—The three of hearts is marked in A's hand, and therefore he holds five trumps.

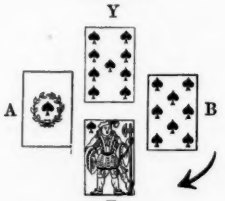
Trick 2.—Z treats his best short suit as a long one, and leads the lowest. We should have preferred to lead the knave of spades.

TRICK 3.



Tricks—AB, 2; YZ, 1.

TRICK 4.

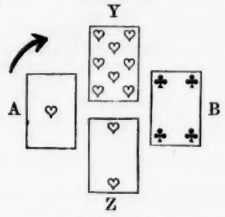


Tricks—AB, 3; YZ, 1.

NOTES.—*Trick* 3.—B is clearly void of trumps.

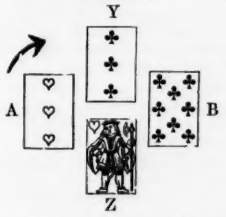
Trick 4.—B has continued with the fourth-best spade, and must hold queen, ten; therefore Y can have no more spades, and the other five are with B or A.

TRICK 5.



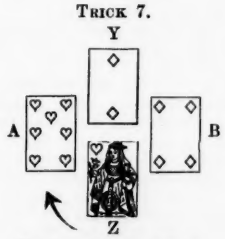
Tricks—AB, 4; YZ, 1.

TRICK 6.



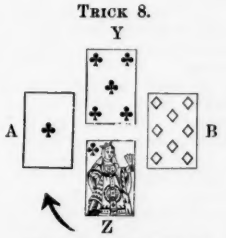
Tricks—AB, 4; YZ, 2.

TRICK 7.



Tricks—AB, 4; YZ, 3.

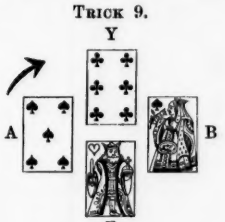
TRICK 8.



Tricks—AB, 5; YZ, 3.

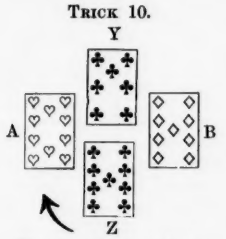
NOTE.—*Trick* 8.—The trick of the hand. The ace of clubs is against Z (see Trick 2); and, if he draws the losing trump before clearing the clubs, there will be nothing to prevent AB from making their spades, save in the unlikely event of A's holding the ace of clubs and B's holding all the spades. Of course, if B holds a card of re-entry in diamonds, or if A holds a winning diamond and two spades, the game cannot be saved by any play.

TRICK 9.



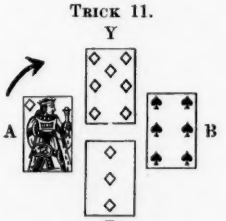
Tricks—AB, 5; YZ, 4.

TRICK 10.



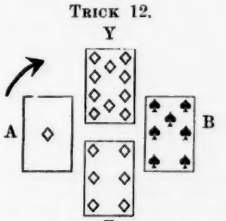
Tricks—AB, 6; YZ, 4.

TRICK 11.



Tricks—AB, 7; YZ, 4.

TRICK 12.



Tricks—AB, 8; YZ, 4.

Trick 13.—A leads the five of diamonds, which Z wins with the queen.

AB SCORE TWO BY CARDS, AND

YZ SAVE THE GAME AND SCORE TWO BY HONOURS.

A's Hand	B's Hand.
H.—Ace, 10, 7, 5, 3.	H.—6.
S.—Ace, 5, 2.	S.—Kg, Qn, 10, 8, 7, 6.
D.—Ace, Kg, 5.	D.—9, 8, 4.
C.—Ace, 10.	C.—Kg, 8, 4.

Y's Hand.	Z's Hand.
H.—8, 4.	H.—Kg, Qn, Kn, 9, 2.
S.—9, 4.	S.—Kn, 3.
D.—Kn, 10, 7, 2.	D.—Qn, 6, 3.
C.—Kn, 7, 6, 5, 3.	C.—Qn, 9, 2.

REMARKS.—It is worth noticing that players who adopt the "plain-suit echo" would infer from A's deuce of spades at Trick 3 that he held not more than three of the suit originally. This information would enable Z, after Trick 4, to place four spades at least in B's hand.

At Trick 4 A reads the remaining spades in his partner's hand, and, having command of the adverse clubs, the two best diamonds, and a card of his partner's suit, he rightly draws two rounds of trumps at Tricks 5 and 6, and may very reasonably have expected to make three by cards even if the honours should prove to be (as was the fact) all in one hand. If Z had opened the diamonds at Trick 8, A after winning with king would have secured the game by leading the losing trump; but A dare not follow this course after parting with his ace of clubs, for if the long clubs should be in one hand he may even lose the game.

Chess Column.

BY I. GUNSBERG.

WE publish below two more games of the recently-played match Blackburne *v.* Lee won by the former player, the final score being Blackburne won 5, Lee won 2, and 7 draws. The ninth game, although weakly played by White, contains some instructive as well as entertaining features. If closely followed, step by step, it may be noticed that while White kept standing still through losing time, Black's effective strength and advantage in position seemed to grow correspondingly with every move. Then, making good use of his superior development, he pushed on his attack at the proper moment, and this resulted in material gain by a very fine combination, of which even Black may be proud, and he finished off the game both elegantly and expeditiously.

Game ten is no less pleasing than its predecessor. Again Blackburne constructs his game in masterly manner, defending himself against the effort of his opponent to take advantage, according to stereotyped rules, of the open file on the QKt line; but at the same time, thinking also of attacking possibilities, he places all his pieces very efficiently, and then suddenly develops the attack on his unsuspecting opponent, and by a very pretty manœuvre on the thirtieth move, he soon gets an overwhelming advantage.

It will be recollected that Lee won both his games from Blackburne and Burn in the Bradford Tournament. This fact, in conjunction with the play in this match, brings into relief very strongly the difference between tournament play and match play. In the former case a strong player playing for a high prize, when meeting an inferior opponent, with whose play he is perhaps not very familiar, tries very hard not to draw against him. Very often, however, the only thing which such players know how to do is to play for a draw. A little nervousness when meeting such a player, or the dread not to lose half a point, will often cause the stronger player to lose. But in a match it is quite different. Then, after two or three games, the stronger player will, so to speak, completely take the measure of his opponent, and if he is in a position not to mind the draw, the weaker player will have no chance whatever.

GAME NO. 9.

FRENCH DEFENCE.

	WHITE. Blackburne.	BLACK. Lee.		WHITE. Blackburne.	BLACK. Lee.
1.	P to K4	P to K3	14.	B × Kt	KtP × B
2.	P to Q4	P to Q4	15.	Kt to K2 (*e*)	R to QKtsq
3.	QKt to B3	KKt to B3	16.	Castles (KR)	Castles (KR)
4.	B to KKt5 (*a*)	B to K2	17.	R to B2 (*f*)	B to Q2
5.	P to K5	KKt to Q2	18.	P × P	Q × P
6.	B × B	Q × B	19.	QKt to Q4	R to Kt2
7.	Q to Q2 (*b*)	P to QR3 (*c*)	20.	Kt × Kt	B × Kt
8.	QKt to K2(*d*)	P to QB4	21.	Kt to Q4	B to Q2
9.	P to KB4	QKt to B3	22.	R to Ksq	KR Ktsq
10.	P to B3	P to B4	23.	Q to Bsq	P to QR4
11.	Kt to B3	P to QKt4	24.	QR to K2	P to R5
12.	P to KR3	Kt to Kt3	25.	P to R3	K to Rsq
13.	Kt to Bsq	Kt to B5		(50 min.)	(55 min.)

WHITE. Blackburne.	BLACK. Lee.
26. P to KKt4 (*g*)	P to Kt3 (*h*)
27. Q to K3 (*i*)	Q to K2
28. R to Kt2	R to KKtsq (*k*)
29. P × P	KtP × P (*l*)
30. R × R (ch)	K × R
31. R to Kt 2(ch)	K to Rsq (*m*)
32. Kt × BP (*n*)	Q to Bsq
33. Kt to Q6	R to Ktsq
34. Q to R7	R to Ksq (*p*)
35. Q × B	R to K2
36. Q to B8	Resigns.
(1 hour 17 min.)	(1 hour 37 min.)

NOTES.

(*a*) This move still holds the field, in spite of 4. P to K5, which took the popular fancy for a time after Steinitz's celebrated Habana game.

(*b*) This used to be the way in which the German players usually met Blackburn's French Defence.

(*c*) Black may castle here; P to R3 is not essentially necessary at this point.

(*d*) The proper square to place this Knight is K3 via Qsq.

(*e*) White seeks to plant his Knight at Q4.

(*f*) White posts his forces in advantageous positions. The Rook on B2 anticipates an attacking design on the QKtP, and is also available for the support of an attack on the King's side should P to KKt4 become feasible.

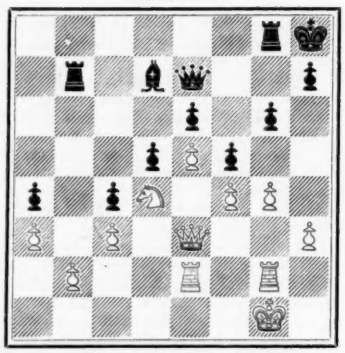
(*g*) A promising venture. White's position is admirably contrived, as he has nothing to fear from Black.

(*h*) P×P 27. P×P, P to Kt3 would also have left White a preponderating advantage.

(*i*) Threatening Kt×BP, and thereby bringing his Queen into better play.

(*k*) R to KBsq would have been met by White with 29. P×P, KtP×P 30. R to Kt5, R (Kt2) to Ktsq, 31. R(K2) to Kt2, R to Ktsq, Kt×BP all the same.

BLACK.—LEE.



WHITE.—BLACKBURNE.

Position after Black's 28th move, R to K Ktsq.

(*l*) KP×P would be followed by P to K6 and Q to K5 (ch).

(*m*) With K to Bsq Black might have held out longer.

(*n*) As effective as it is pretty. If P×Kt 33. P to K6, then the check on Q4 kills Black.

(*p*) If R to Qsq 35. Q to B7, threatening Q×R.

GAME No. 10.

ZUKERTORT'S OPENING.

WHITE. Lee.	BLACK. Blackburne.	WHITE. Lee.	BLACK. Blackburne.
1. KKt to B3	P to Q4	16. Kt to KB3	Castles
2. P to Q4	B to Kt5 (*a*)	17. Kt to B5 (*i*)	B×Kt
3. Kt to K5 (*b*)	B to B4	18. P×B	P to K4
4. P to QB4 (*c*)	P to KB3	19. Q to R4	B to Ksq (*k*)
5. Kt to KB3	P to B3	20. R to Bsq	P to K5
6. P×P	P×P	21. Kt to Ktsq (*l*)	P to B4 (*m*)
7. Kt to B3	P to K3	22. B to K2	Q to K3
8 Q to Kt3	Q to Q2	23. P to Kt4 (*n*)	Kt to K4
9. Kt to KR4 (*d*)	B to KKt5	24. Q to Qsq	P×P
10. P to K3	Kt to B3	25. P×P	Q×P (*o*)
11. P to QR3 (*e*)	R to Bsq	26. B to QB3	Q to Kt7
12. B to Q2	B to Q3	27. B×Kt	Q×R
13. Kt to R4 (*f*)	KKt to K2	28 K to Bsq	B to Q2
14. P to R3 (*g*)	B to R4	29. P to B3	B to R6 (ch)
15. P to Kt4 (*h*)	B to KB2	Resigns (2 hours).	
(36 min.)	(42 min.)		

NOTES.

(*a*) The move commits Black to an attack on the King's side, because it leaves his Queen's wing weak for the end game. Independent of this question, I think Black should not play B to KKt5 before White has moved his KP.

(*b*) Experience has not yet confirmed this move sufficiently. In advancing thus early, the Knight is exposed to wind and weather.

(*c*) P to K3 followed by B to Q3 might be employed to better advantage than the test move.

(*d*) White does not get much comfort out of this move. This is the second time this Knight has attacked the Bishop on a square from which he will have to retire.

(*e*) White does not seem to have any settled plan of action, and is losing ground in consequence.

(*f*) This move adds to the list of wasted opportunities for making developing moves.

(*g*) All this helps Black, whose Bishop is better posted on B2 than Kt5.

(*h*) This move adds additional weakness to White's game.

(*i*) It matters little what White does, as his game is hopelessly compromised, but this move facilitates Black's advance in the centre.

(*k*) Black evidently intends to advance on the KB file and B to Ksq. While preparing for this, also threatens other contingent dangers, such as Kt to Q5, &c., which, under circumstances, might become dangerous.

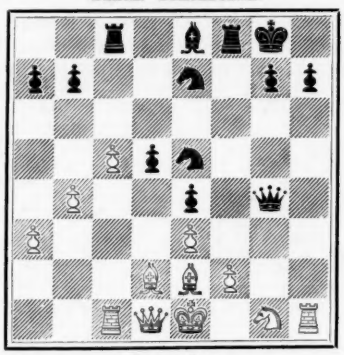
(*l*) If I had to illustrate the meaning and importance of losing time I should chose the moves of the Knight in this game as a good example. Out of 21 moves made, White has made 6 ineffective moves with this Knight, and has now again reached his starting-point, namely, 1. Kt to KB3, 2. Kt to K5, 3. Kt to KB3, 4. Kt to KR4, 5. Kt to KB3, 6. Kt to Ktsq.

(*m*) Black increases his advantage with every move.

(*n*) Even if White had guessed the beautiful combination which Black was working out, he could do little else except Q to Qsq.

(*o*) A surprisingly fine conception. Of course if B×Q, mate in two follows. Diagram appended.

BLACK.—BLACKBURNE.



WHITE.—LEE.

Position after Black's 25th move, Q × P.

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